HACCP-Based Program to Control *Cryptosporidium* and other waterborne pathogens in the Alameda Watershed

An Introduction to HACCP-Based Water Quality Programs

Submitted to
the San Francisco Public Utilities Commission

By the Alameda County Resource Conservation District cooperating with

- San Francisco Water Department
- University of California Cooperative Extension
- USDA Natural Resources Conservation Service
- USDA Animal and Plant Health Inspection Service - APHIS - VS
- California Department of Fish and Game
- Alameda County-Wide Clean Water Program
- Regional Water Quality Control Board
- East Bay Regional Park District
- East Bay Municipal Utilities District
- Alameda County Water District
- University of California Animal Agriculture Research Center
- California Cattlemen's Association
- US Environmental Protection Agency
- Alameda County Agricultural Commissioner
- California Department of Health Services
- Farm Bureau, Santa Clara County
- Grazing Lessees of San Francisco Water Department Lands

For more information contact:
Sheila Barry, Alameda County Resource Conservation District
1615 Barcelona St, Livermore, CA 94550
(510) 371-6078; FAX (510) 371-0155; Email sjgaertner@ucdavis.edu

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Foreword

Waterborne infection with *Cryptosporidium parvum* has become a leading public health issue due to the severity of the disease for immunosuppressed humans, recent waterborne outbreaks of cryptosporidiosis in metropolitan areas of the United States, and the presence of this parasite in 50-90% of U.S. rivers. The most notable outbreak of waterborne cryptosporidiosis in humans was the estimated 400,000 cases in Milwaukee, Wisconsin, in 1993. Federal and state public health officials, government land managers (e.g., U.S. Forest Service), and regional water districts are under considerable pressure to reduce the risk of waterborne cryptosporidiosis in humans. As a consequence, national regulations are being proposed that will first monitor (U.S. EPA's Information Collection Rule) and then explicitly regulate (U.S. EPA's Enhanced Surface Water Treatment Rule) the levels of *C. parvum* in drinking and source water. If it is found that a water district's source of water is highly contaminated with *C. parvum*, the district will have to either improve water treatment procedure, reduce upstream contamination of water or some combination of these two approaches. It is the second approach, reducing contamination of source water, that not only involves veterinary medicine, animal agriculture and wildlife management, but also requires accurate information regarding the source(s) of this waterborne pathogen.

The primary quantitative source(s) of *C. parvum* are not known; however, the assumption that livestock are the primary reservoirs of waterborne infection for humans has recently led to concerns from land and watershed managers, the livestock industry, and university researchers. The location of livestock production systems such as dairy farming and cow-calf operations and the use of horses and mules in certain backcountry and suburban watersheds is being questioned throughout California. The assumption, not yet confirmed by research, is that cattle and horses pose an unacceptable risk to water quality and human health. The concern is that *C. parvum* oocysts shed in the feces of domestic animals may be directly deposited or inadvertently washed into nearby bodies of water. Assuming these bodies of water are used for human consumption, these oocysts would need to survive the passage downstream, survive water treatment procedures, and be in sufficient concentration so as to initiate infection in susceptible humans when ingested. Although such a scenario is possible, it has yet to be shown for the environmental conditions present in California. On the other hand, it has yet to be shown that this route of infection is *not* occurring in California. In protecting the public's health, we must be certain that actions taken to reduce or eliminate one public health risk do not initiate or amplify other risk(s).

There is no doubt that improper grazing management can degrade natural resources and compromise water quality; however, proper grazing not only protects water quality, but is also the best management tool for conserving some of California's unique natural ecosystems. In particular, grazing has proven to be an effective tool for managing some wildlife habitats and ecosystem types within California's annual grasslands. On San Francisco Water Department lands, grazing livestock consume approximately 9 million tons of vegetation annually. In the US Fish and Wildlife Service's biological opinion for the Los Vaqueros Reservoir Project in Contra Costa County, livestock grazing is a requirement for the protection of habitat for the San Joaquin kit fox and the red-legged frog. The kangaroo rat and predatory birds, such as the Golden Eagle, have also been shown to benefit from proper grazing practices. In addition to improving wildlife habitat, grazing the annual grassland can enhance vegetation, by promoting native perennial plants, native forbs and wildflowers, and controlling evasive weedy plants.

Regarding water quality, with proper grazing management, the risk of livestock contaminating surface water can be minimized, while significant protection from fire hazards can be achieved. Grazing significantly reduces the fire hazard on California's annual grasslands by reducing fuel load and the invasion of woody plants. Without grazing, fire management practices, such as clearing fire breaks and/or additional discing which may accelerate erosion will be required. For example, during the drought more discing was performed on San Francisco watershed lands because of reduced cattle grazing in the watershed. Although fire management practices can increase erosion, they typically decrease the potential for water quality contamination by decreasing the likelihood of a wild fire. The increased erosion that follows a wild fire is one of the greatest potential contaminant sources to surface water on California's annual grasslands.

A fire results in loss of vegetation, which exposes the soil to direct impact of raindrops, reduces the infiltration capacity, and increases runoff and the movement of sediment. Sediment can be a major carrier for pathogenic organisms, organic residues, nutrients, and pesticides. It can also clog stream channels and reduce the capacity of reservoirs. At the treatment plant, sediment causes additional problems. The increase in turbidity from the fine particles results in increased treatment operations (e.g. more backwashing of filters, higher disinfectant dosages). The risk of pathogens slipping through the treatment process is also increased. Clearly, a wild fire could have a very serious impact upon water quality.

The primary concern of the San Francisco Public Utilities Commission in the Alameda watershed is water quality. As identified in the Preferred Watershed Management Alternative, the primary goal for watershed management is to maintain and improve source water quality to protect public health and safety. At the request of the public, the Commission decided to reconsider aspects of the Preferred Alternative relating to livestock grazing and with the recognition that the livestock industry may be able to provide improved management practices that would reduce the risk of waterborne pathogens. Involving the livestock industry is important for addressing water quality issue on a "watershed" scale. Only 30% of the Alameda Watershed is owned by the city and county of San Francisco.

On March 4, 1997 the Commission passed a resolution asking the General Manager to solicit from the Alameda County Resource Conservation District and the livestock industry a comprehensive best management practices plan designed specifically to include risk assessment and monitoring programs guarding against *Cryptosporidium* and other waterborne pathogens. Commissioner Victor Makras supported the resolution on the premise that the plan fulfills the following criteria: " maximum water quality, maximum fire protection, and maximum watershed protection; eliminating or minimizing or containing the risks". The Resource Conservation District and the livestock industry has responded by adapting the USDA-FDA system, Hazard Analysis of Critical Control Points (HACCP), a systematic, proactive program synonymous with food safety, to address water quality issues and watershed protection. This program provides "real" safeguards for protecting water quality and minimizing fire hazards through the application of sound watershed management practices with monitoring and science-based controls. By adopting a HACCP-based water quality plan, the San Francisco Water Department will demonstrate leadership and support of a science-based watershed program that watershed land owners and managers that own the remaining 70% of the Alameda watershed should be willing to participate in.

Executive Summary

On March 4, 1997 the San Francisco Public Utilities Commission passed a resolution asking the General Manager to solicit from the Alameda County Resource Conservation District and the livestock industry a best management practices plans that includes risk assessment and monitoring to guard against *Cryptosporidium* and other waterborne pathogens. The district and industry has responded by adapting Hazard Analysis of Critical Control Points (HACCP), a systematic, proactive program synonymous with food safety, to address water quality issues and watershed protection.

HACCP is a system developed nearly 30 years ago for the U.S. Army and NASA. The challenge was to perfect a "zero defect" program to guarantee safety of foods for astronauts while in space. The program focused on preventing hazards that could cause foodborne illnesses by applying science-based controls. Although HACCP was designed and has been specifically adapted to ensure food safety, protecting and improving water quality also requires the prevention and control of potential hazards. Applying HACCP to address water quality concerns means working to eliminate potential contaminants from ever getting in source water. A systematic, proactive approach like HACCP could clearly improve our ability to protect and improve water quality. The San Francisco Public Utilities Commission would be the first water management agency to apply this state-of-the-art approach to address water quality.

This document describes a comprehensive HACCP-based program for livestock grazing management and wildlife management guarding against *Cryptosporidium* and other waterborne pathogens in the Alameda watershed. The San Francisco Public Utilities Commission is urged to continue and complete the development of a HACCP-based water quality management program for the Alameda watershed and for the entire San Francisco water system.

The first step to implementing a HACCP program is to assemble a multidisciplinary team. In order to address potential biological contaminants in the Alameda watershed, a multidisciplinary team, which included locals with knowledge of the watershed and/or water issues and technical experts, was formed. The team recognized that there were several management practices (critical control points) that could be recommended that should eliminate the potential risk from cattle contaminating source water with *C. parvum* and should significantly reduce the risk that feral pigs and other mammalian sources contaminate source water. However, they also noted that there is not currently enough information to complete a hazard analysis and only through a comprehensive monitoring program can potential sources of these protozoa be identified and water users be assured that watershed management actions implemented to guard against *C. parvum* and other waterborne pathogens are indeed effective.

A comprehensive watershed monitoring program for pathogens should include monitoring fecal samples from selected livestock and wildlife populations in conjunction with strategic water testing. Testing fecal samples identifies animals that shed these parasites. If a population of animals fail to shed these protozoal parasites, they do not represent a hazard. If a population of animals are shown to be infected with these parasites, then strategic water testing will indicate if

the environmental conditions are present to allow source water contamination to occur. In addition to providing assurances to San Francisco water users, this monitoring program will be essential for documenting and determining watershed management practices that can and will be applied on all watershed lands. San Francisco only owns about 30% of the Alameda watershed. Implementing voluntary (Best Management Practices) BMPs on neighboring privately and publicly owned lands in the watershed will require cooperation and a knowledge of scientifically sound BMPs. This monitoring program addresses the monitoring recommendations in the Watershed Sanitary Survey compiled for the Alameda Watershed.

Livestock grazing and wildlife management practices with monitoring and control measures have been developed for the Alameda watershed to guard against *Cryptosporidium* and other waterborne pathogens. These practices are based on the best current scientific information and should be amended as monitoring information and research findings provide additional information.

The greatest risk from cattle contaminating source water occurs if infected cattle directly deposit fecal matter in source water. Livestock and grazing management practices that exclude potentially infected cattle, like young calves, from direct contact with source water may eliminate almost all of the risk associated with cattle contaminating surface water with *C. parvum* or *G. duodenalis*.

In addition to managing livestock to minimize the risk of them contaminating source water with pathogens, livestock should also be managed to reduce fire hazards and control ecological balances. Avoiding the situation where an area of the watershed, particularly near source water, is dominated by a wildlife species (i.e. ground squirrels, rodents) is an important control measure to minimize risks of pathogens contaminating water. Further assessment of wildlife populations to determine associated risks is necessary to develop more specific wildlife management strategies.

There is some data to suggest that feral pigs may contaminate nearby surface water with *Cryptosporidium parvum* and *Giardia duodenalis*. In 1995 a California study found that 5% and 8% of the feral pigs sampled during the summer were shedding *C. parvum* oocysts and *Giardia* cysts, respectively. If infected, the potential for pigs to contaminate surface water may be significant because they focus activities (wallowing and foraging) around the margins of seeps, springs, ponds, streams and lakes during the summer months. In the Alameda watershed, feral pigs have direct access and can deposit fecal material directly into the reservoirs and perennial streams. It is estimated that there may be 1000 feral pigs in the Alameda Watershed. Feral pig populations can be reduced with a persistent, flexible control program.

The management practices described as part of this HACCP-based water quality program should eliminate the potential risk of cattle contaminating source water with *C. parvum* and other waterborne pathogens and should also significantly reduce the risk from feral pigs and other wildlife sources. By implementing these management practices and conducting further assessments with monitoring program real safeguards for protecting water quality are provided to the water users of the San Francisco water system.

Table 1. Summary of Associated Risk, Critical Control Points and Best Management Practices by Management Area for Controlling Biological Contaminants in the Alameda Watershed.

Management Area: Livestock / Grazing

Associated Risk	Critical Control Points	Best Management Practices
Wild fire in the watershed increasing runoff and movement of sediment, which may carry pathogens.	Control Point 3 (pg 29). Manage residual dry matter (RDM) to reduce fire hazard.	Manage grazing livestock to achieve a target RDM of 700-1000 lbs / acre. Specific RDM target levels for each grazing unit are prescribed in the grazing unit plan (appendix I)
Infected cattle directly depositing feces into source water. (Infected cattle are primarily calves less than 4 months of age).	Control Point 1 (pg 26). Minimize the intensity of infection in cattle.	Livestock owners (lessees) establish a herd health program for the prevention and care of general parasitic disease, to maintain healthy immune systems, and minimize diarrheal infection.
	Control Point 2 (pg 27). Control cattle grazing and access to reservoir and riparian areas with fencing.	Maintain reservoir and riparian pastures (buffers) around reservoirs and streams with riparian habitat. These pastures will be managed as non-calf, non-corral pastures. Reservoir and riparian pastures are defined in the grazing unit plan (pg 21)
Infected cattle depositing feces in the watershed where runoff may carry viable pathogens to source water.	Control Point 3 (pg 29). Manage residual dry matter (RDM) to minimize potential for feces transport (minimizing runoff).	Insure good even distribution of livestock utilization and fecal material by controlling grazing utilization and distribution. Control grazing utilization to achieve target RDM levels to meet specific resource objectives including water quality for each grazing unit (Appendix I)
	Control Point 4 (pg 32). Strategically locate areas of livestock concentration	Areas of livestock concentration should be hydrologically remote. Stock tanks and feeders should not be located in stream channels, swales or flood plains. Water development may relocate cattle concentration to more appropriate locations.

Management Area: Feral Pigs

Associated Risk	Critical Control Points	Best Management Practice
Infected feral pigs contaminating source water	Control Point 1 (pg 36). Minimize the population and infection rate of feral pigs.	Pig densities should be reduced with a persistent, flexible control program.

Management Area : Wildlife

Associated Risk	Further Assessment
Infected wildlife contaminating source water	Further Assessment is necessary to determine associated risk, identify critical control points and develop best management practices for wildlife management (pg 34).

Management Area: Human/Recreation

Associated Risk	Critical Control Points	Best Management Practice
Infected humans or companion animals contaminating source water.	Minimize the opportunity for contaminating source water (pg 43).	Public Education and adequate restroom facilities (location, number).

Management Area: Sunol Filter Treatment Plant

Associated Risk	Critical Control Points	Best Management Practice
Sunol Filter Treatment Plant is the final barrier of protection before water reaches water users.	Filter and remove from system, or render unviable any biological contaminants that reach the filter plant (pg 45).	To Be Developed

Introduction to a HACCP-based Program for Addressing Water Quality in the San Francisco Water Storage, Collection and Distribution System

HACCP (Hazard Analysis Critical Control Points) is a system developed nearly 30 years ago for the U.S. Army and NASA. The challenge was to perfect a "zero defect" program to guarantee safety of foods for astronauts while in space. The program focused on preventing hazards that could cause foodborne illnesses by applying science-based controls. In the early 1970s, the Pillsbury Corporation put the HACCP approach into practice in the food-processing industry. It has since been adopted by other food service and manufacturing industries. With newly emerging and re-emerging foodborne illnesses gaining public attention, in 1994 the Food and Drug Administration (FDA) introduced a rationale for mandating HACCP among retail stores and processing plants to prevent food safety problems.

The overall focus of any HACCP program is to prevent the occurrence of an identifiable hazard. The program emphasizes control of a process as far "upstream" as possible. Although HACCP was designed and has been specifically adapted to ensure food safety, protecting and improving water quality also requires the prevention and control of potential hazards. Applying HACCP to address water quality concerns means working to eliminate potential contaminants from ever entering source water. A systematic, proactive approach like HACCP could clearly improve our ability to protect and improve water quality. The San Francisco Public Utilities Commission would be the first water management agency to apply this state-of-the-art approach to address water quality.

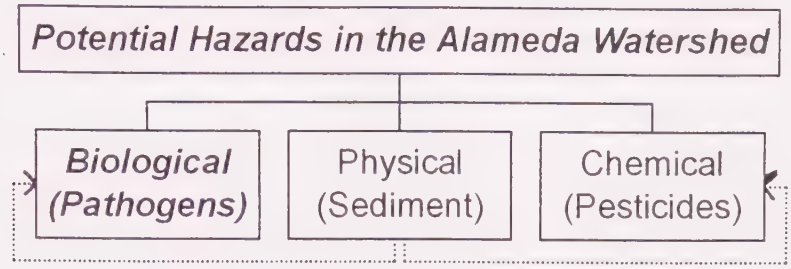
Implementing a HACCP-Based Water Quality Program

Steps for implementing a HACCP-based water quality program are presented in Table 2. These steps are illustrated in this document by providing a HACCP-based Water Quality Program to address potential biological hazards (pathogens) in the Alameda Watershed. Although this program specifically targets biological hazards and is not a complete HACCP-based water quality program for the entire San Francisco water system, it does establish and demonstrate the thought process and application of a water quality management program using HACCP methodology. It also thoroughly describes a comprehensive HACCP-based program for livestock grazing management and wildlife management while guarding against *Cryptosporidium parvum* and other waterborne pathogens in the Alameda Watershed.

San Francisco Public Utilities Commission (PUC) is urged to continue and complete the development of a HACCP-based water quality management program for the Alameda watershed and for the entire San Francisco water system. A complete HACCP-based water quality program for the Alameda watershed is outlined in this document. In addition to addressing control of biological hazards (i.e. pathogens), it would address control of physical hazards (sediment) as well as chemical hazards (i.e. pesticides, herbicides) in the Alameda watershed (figure 1). A complete

plan for the entire San Francisco water system would establish controls for potential hazards in the Hetch Hetchy system and Peninsula watershed.

Figure 1. Potential Hazards to be addressed by a HACCP Water Quality Plan for the Alameda Watershed.



It should be recognized that this first attempt at adapting HACCP to water quality issues will create questions as well as answers. In some cases adequate research is not yet available to identify all the hazards, critical control points and monitoring actions for water quality issues. However, outlining a HACCP-based water quality program for the entire San Francisco Water Department system will help us better define these questions and establish relevant monitoring and research activities to address them. Implementing a HACCP-based water quality program will require a large commitment of resources for monitoring and research, but will be a very proactive way to address water quality concerns throughout a watershed.

Much of the information needed to outline a HACCP-based water quality program for both the Alameda and Peninsula watersheds is available from the Watershed Sanitary Survey and/or in the Watershed Management Plans that are currently being developed. With only a few modifications, this information could be implemented into a HACCP-based water quality program. Information in the Sanitary Survey for the Hetch Hetchy system should assist in developing an outline for a HACCP-based water quality program for that system.

There are a number of advantages of developing a HACCP-based water quality program to implement the watershed sanitary surveys and/or watershed management plans. A HACCP-based water quality program:

- Implements recommendations from the Watershed Sanitary Survey.
- Implements management actions outlined in the watershed management plan with monitored control measures.
- Includes mandatory recordkeeping that allows for verification of the HACCP program over time.
- Provides an information system to continue to address potential hazards.
- Provides a framework for on-going assessment for potential hazards.

With consumers' apprehensions growing with regard to waterborne illness, a verifiable water quality management program like HACCP is just smart business.

Table 2. Steps for Implementing a HACCP-based Water Quality Program

1. Assemble a multidisciplinary, watershed-based HACCP team.
2. Identify the beneficial uses of the water in the system.
3. Describe the water processing requirements required to meet the beneficial use.
4. Develop a schematic diagram that describes the collection, storage and distribution of the water.
5. Verify the schematic diagram.
6. Implement Principle 1: Conduct a hazard analysis. Potential hazards (biological, chemical, or physical) associated with water are identified.
7. Apply Principle 2: Identify critical control points. These are points in the collection, storage, and distribution of water - from raindrop to end-use (i.e. tap) - where a potential hazard can be controlled or eliminated.
8. Apply Principle 3: Establish preventive measures with critical limits for each control point.
9. Apply Principle 4: Establish procedures to monitor the control points.
10. Apply Principle 5: Determine corrective actions to be taken when monitoring shows that a critical limit has not been met.
11. Apply Principle 6: Establish effective recordkeeping to document the HACCP system.
12. Apply Principle 7: Establish procedures to verify that the system is working consistently.

The HACCP-based Water Quality Program to Control Biological Hazards in the Alameda Watershed

Step 1

Assemble a multidisciplinary, watershed-based team. In order to address potential biological contaminants in the Alameda watershed, a multidisciplinary team, including individuals with knowledge of the watershed, water issues and other technical experts, was formed. The team consists of the following members:

Sheila Barry, Alameda County Resource Conservation District, *Team Coordinator*
Dr. Rob Atwill, University of California Vet-Med, Environmental Animal Health Specialist
Dr. Ken Tate, University of California Cooperative Extension, Range Hydrology Specialist
Dr. Lee Fitzhugh, University of California Cooperative Extension, Wildlife Specialist
Dr John Maas, University of California Cooperative Extension, Beef Cattle Health Specialist
Dr. Jim Cullor, University of California, Dir.Vet-Med Teaching & Research Center, HACCP Specialist
Dr. Jim Clawson, University of California Cooperative Extension, Range Specialist Emeritus
Dr. Kristen Charlton, CA Department of Fish and Game, Wildlife Veterinarian
Tim Koopman, Land Agent, San Francisco Water Department
Terry Huff, District Conservationist, USDA Natural Resources Conservation Service
John Gouvia, Biologist, Alameda Agriculture Commission
Joann Carlton, Biologist, CA Department of Fish and Game

A group of lessees and SF Water Department watershed keepers was brought together to work on developing and implementing the grazing unit plan:

Darrell Sweet, Livestock Manager, Sparrowk Livestock
Danny Torres, On-site Livestock Manager, Sparrowk Livestock
Bob Pombo, Livestock Owner/Manager
Jim and Virginia Coelho, Livestock Owner/Manager
Russ and Tony Fields, Livestock Owner/Manager
Robert and Bud Nielsen, Livestock Owner/Manager
Ann Vasser, Livestock Owner/Manager
Mike Byrne, SF Water Department watershed keeper
Frank Marino, SF Water Department watershed keeper

Due to the short time frame required by the San Francisco PUC, a review process was initiated to permit additional input from a broad base of stakeholders. Those providing input through the review process included:

Mike Finn, Department of Health Services, Drinking Water Field Operations
Dale Bowyer, Regional Water Quality Control Board
Ken Burger, East Bay Regional Parks District
Dr. Jack Colford. UC Berkeley Department of Public Health
John Stechman, La Cuesta Environmental Consulting
Eric McGuire, Marin Municipal Water District
George Gough, California Cattlemen's Association
Ian Garnett, University of California Animal Agriculture Research Center
Jim Reynolds, Alameda County Water District
Obaid Kahn, Alameda County-Wide Clean Water Program
Tina Stott, EDAW Inc.
Lisa Gallina, Public Affairs Management
Tony Leone, Alice B. Tokelas Lesbian and Gay Democratic Club
Bruce Macler, US Environmental Protection Agency
Oren Pollack, The Nature Conservancy
Marguerite Young and Dan Rounds, Clean Water Action
Rodd Tripp, East Bay Municipal Utilities District
James Hawley, Private Landowner Alameda Watershed
Nancy Richardson, Santa Clara County Farm Bureau
Dr. Utterback, USDA-APHIS-VS

Step 2

Identify the beneficial uses that determine the quality of water required throughout the system.
One critical beneficial use of the water in the Alameda watershed is drinking water. In California, the Department of Health Services stipulates and sets water quality monitoring standards for drinking water. In regards to potential biological hazards, raw water from the reservoirs is tested for presence of coliform bacteria. The San Francisco Water Department Water Quality Division

has reported that water tests from 1969 to 1989 indicate that coliform bacteria were typically less than a few hundred per 100mL in the Alameda reservoirs.

The EPA has proposed national regulations for *Cryptosporidium* and *Giardia*. The San Francisco Water Department has been intensively monitoring all three of its sources (Alameda watershed, Peninsula watershed, Hetch Hetchy system) for *Cryptosporidium* and *Giardia* since January 1993. Two methods of testing has been used. From January 1993 through October 1994, proposed Standard Method 9711B (without differential interferences contrast microscopy) was used. Cryptosporidium and Giardia were detected in a few samples from all three sources; however, this method did not determine whether these oocysts or cysts were viable. Since November 1994, the ICR method has been used. Using the ICR method, monthly water tests have not detected viable *Cryptosporidium* oocysts or *Giardia* cysts in samples from either Calaveras or San Antonio Reservoir. The methods for environmental sampling of *Cryptosporidium* have problems with recovery rates, accuracy and are expensive. It is not only costly to perform a large number of samples, but it is also difficult to draw conclusions or to make comparisons about water quality because of these problems.

Step 3:
Describe the water processing (filtration, treatment) requirements necessary to meet the beneficial use. The federal and state surface water treatment regulations are based on a multibarrier approach to pathogen reduction. Watershed management and protection is one of those barriers. Advanced treatment cannot completely substitute for protection of the watershed and is usually more expensive. The Surface Water Treatment Rule (SWTR) stipulates that surface water supplies must undergo a multibarrier treatment to remove and inactivate waterborne pathogens. The Department of Health Services (DHS) has determined that all surface waters in California are subject to potential contamination from *Giardia lambia* and viruses. Current tests (over the past year and a half have not detected viable Cryptosporidium oocysts or Giardia cysts in either Calaveras or San Antonio Reservoirs (SFWD, Water Quality Division Data).

In accordance with the SWTR, DHS requires 99.9 (3 log) reduction of Giardia cysts and a 99.99 percent (4 log) reduction of viruses, to be achieved through filtration and disinfection. According to the Watershed Sanitary Survey completed in October 1995, the Sunol Water Treatment Plant treating all water coming from Alameda watershed is effectively meeting all current regulations pertaining to the SWTR.

Step 4:
Develop a schematic diagram that describes the collection, storage and distribution of the water throughout the system. Although this HACCP-program deals only with the Alameda watershed, it is important to understand the entire San Francisco water system. The system provides the opportunity for water from one part of the system to be blended with water from other parts of the system. For example, Hetch Hetchy water can be stored in the San Antonio Reservoir. Clearly, in order to completely address and work to control the potential water quality hazards in

the San Francisco water system, all watersheds which feed the system will need to be part of a HACCP-based program.

The following provides an overview of the entire San Francisco water system and a detailed description of the Alameda Watershed (Watershed Sanitary Survey, 1995).

Overview of the San Francisco Water System

Three primary sources provide the surface water supplies for the entire San Francisco water system: the Tuolumne River in the Sierra Nevada mountains via the Hetch Hetchy system; surface runoff captured from the Alameda watershed; and surface runoff captured from the Peninsula watershed. San Francisco also obtains some water from ground water basins in San Francisco, Pleasanton, and the Sunol Valley. During drought, water has also been purchased (1991, 1992) from the state of California to augment primary sources. Approximately 80 to 85% of the potable supply to San Francisco Water Department (SFWD) customers is from the Hetch Hetchy system.

A schematic of the overall water system is presented in Figure 2. Water is conveyed to the San Francisco Bay Area from the Hetch Hetchy system across the San Joaquin Valley through a series of aqueducts and tunnels to Alameda County near the community of Sunol. Some of the Hetch Hetchy water is stored in the San Antonio Reservoir (Alameda Watershed), while the remainder flows through the Irvington Tunnel and the Bay Division Pipelines. Sunol Valley ground water and water purchased from the State can also be stored in San Antonio Reservoir.

Water including local runoff in the Alameda Watershed Reservoirs is treated at the Sunol Filter Treatment Plant and is combined with the Hetch Hetchy water flowing through the Irvington Tunnel and Bay Division Pipelines. This water is then conveyed across the San Francisco Bay and distributed to wholesale customers along the way. Part of this water is stored in the Peninsula Reservoirs where it is blended with local runoff; the remainder is conveyed to wholesale customers along the Peninsula and individual customers within the City. The water stored in the Peninsula Reservoirs is treated at Harry W. Tracy filter plant. This water continues on to San Francisco customers.

The Alameda Watershed

The Alameda Creek watershed lands are located in the Diablo Range portion of the Central Coast Range. The watershed, 633-sq. miles, extends from Mount Diablo in the north, to the Altamount Pass in the east, to Mount Hamilton in the south, and Niles Canyon to the west (Figure 3). It is located within Contra Costa, Alameda, and Santa Clara counties. The watershed is divided into the Livermore and Sunol drainage units.

The Livermore drainage unit occupies 423 sq miles within the northern and eastern part of the watershed. The major streams flowing through the Livermore drainage unit are Arroyo del Valle, Arroyo las Positas, Arroyo Mocho, Alamo Creek, San Ramon Creek, and Tassajara Creek. Arroyo del Valle and Arroyo Mocho drain the largest areas, converging to form the Arroyo de la Laguna on the floor of the Livermore-Amador Valley. Sinbad and Vallecitos Creeks join Arroyo de la Laguna before it joins Alameda Creek in the Sunol drainage unit in Sunol. The contribution of this drainage as a water source to the San Francisco water system is minimal. However, it should be considered when interpreting future water quality data. The Sunol Filter Galleries can pick up water from the Arroyo de la Laguna. In addition, if a significant water quality problem occurs in Arroyo de la Laguna, it could impact the surface and groundwaters in and around the Filter Galleries. The HACCP-based water quality program presented in this document will focus on management within the Sunol drainage.

The 210-sq mile, Sunol drainage unit is located in the southern half of the watershed and contains the San Francisco Water Department reservoir lands, covering 63 sq. miles. This drainage can be divided into four subareas (Figure 4):

- The Calaveras drainage area includes lands adjacent to the Arroyo Hondo and the Calaveras Reservoirs. Arroyo Hondo is the principal tributary to Calaveras Reservoir, capturing the runoff from nearly 60 percent of the watershed. Two of the tributaries to Arroyo Hondo, Smith and Isabel Creeks, circle Mount Hamilton, one of the highest points in the watershed.
- The Upper Alameda drainage area includes lands along the Alameda Creek upstream of the Alameda Diversion.
- The San Antonio drainage area includes the entire watershed of San Antonio Reservoir. San Antonio Reservoir receives water from San Antonio, Indian, La Costa, and Apperson Creeks in addition to imported water from Hetch Hetchy, the State via the South Bay Aqueduct (in an emergency), and the Sunol Filter Galleries, which may include groundwater, water from the Livermore drainage unit and Lower Alameda drainage.
- The Lower Alameda drainage area includes the lands downstream of the Alameda Diversion Dam and downstream of the two reservoirs, all of which drains to the Sunol Filter Galleries.

Land use and activities closest to the reservoirs and reservoir tributaries (the Calaveras, Upper Alameda, and San Antonio drainages) have been of more concern to the San Francisco Water Department, than uses downstream of reservoirs which drain to the Sunol Filter Galleries. This is because the Filter Galleries only contribute a small amount of water, provide limited storage, and can be temporarily removed from the system. However, as recognized in the Watershed Sanitary Survey, water quality contributing to the Filter Galleries should not be allowed to degrade since this is also a potential source of water for the City. A HACCP-based water quality program should allow for continued monitoring, development. and implementation of best management practices. These practices based on sound-science and natural resource management principals can be implemented throughout the watershed.

In addition, even within the drainages closest to reservoirs and reservoir tributaries, the San Francisco Water Department is not the sole land owner. To really provide safeguards for the water supply, San Francisco PUC must work closely with local landowners throughout the watershed in implementing sound, scientifically based land use practices and principles.

Step 5:
Verify the schematic diagram

Steps 6 – 12:
Application of HACCP principles to control hazards in the Alameda Watershed is described in the sections that follow in this document.

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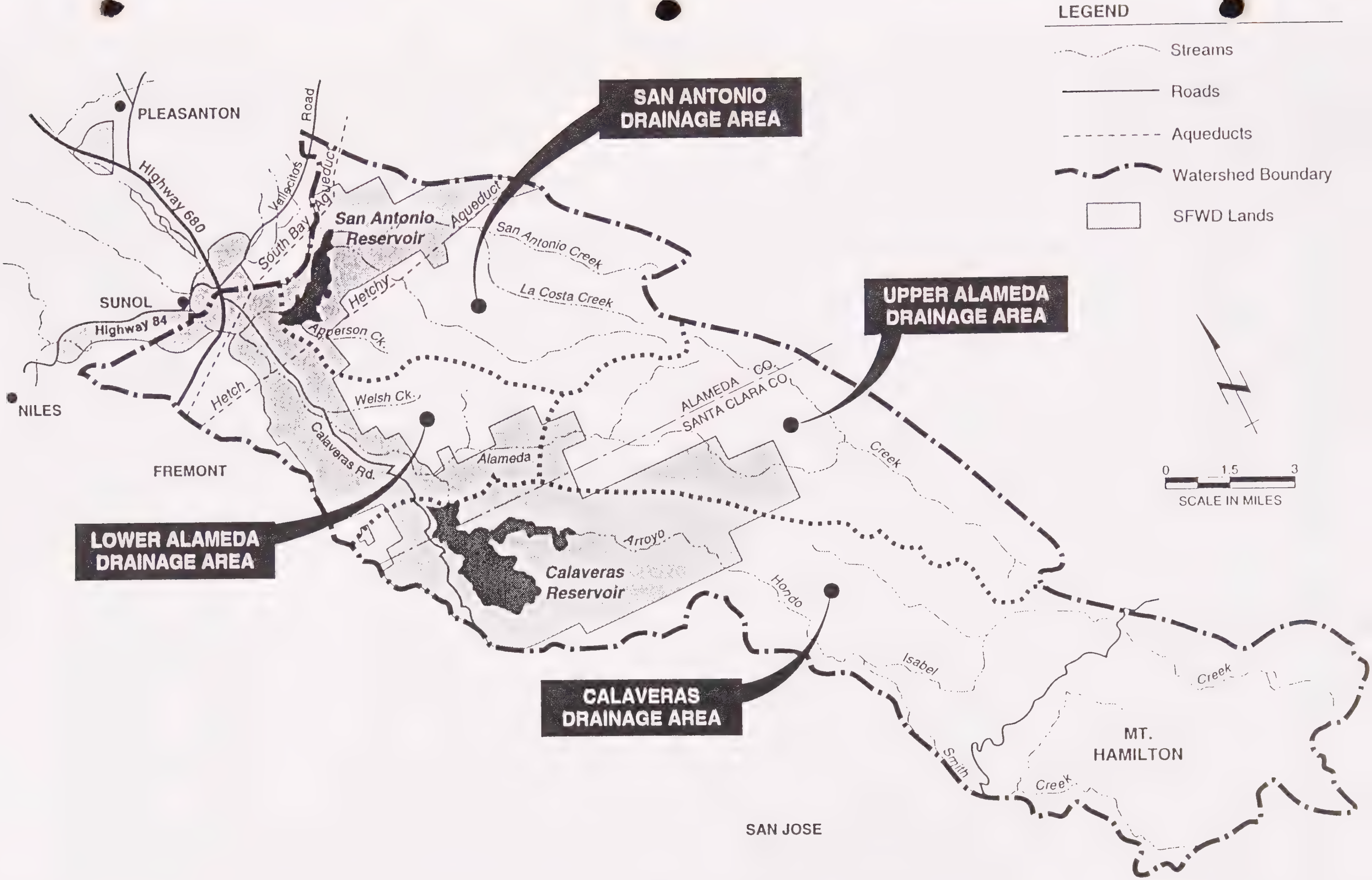

ALAMEDA WATERSHED DRAINAGE AREAS

FIGURE 4

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MONTGOMERY WATSON

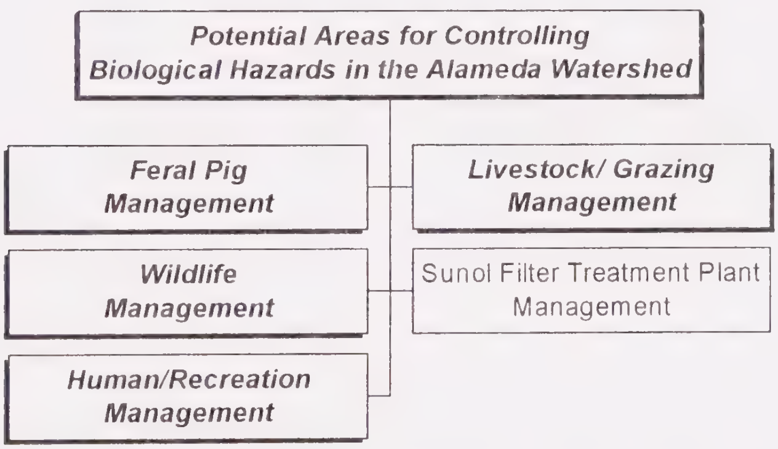
Application of HACCP Principles to Control Biological Hazards in the Alameda Watershed

Hazard Analysis

Step 6

Implement Principle 1: Conduct a hazard analysis. Although futher assessment as described in the **Watershed Water Quality - Pathogen Monitoring Protocol** is necessary to clearly identify hazards, an initial analysis of biological hazards in the Alameda watershed identified five management areas for management controls (figure 5). The following sections of this document outline Steps 7 - 11 for implementing a HACCP-based water quality control program for the each management area, except the Sunol Filter Treatment Plant. The Sunol Filter Treatment Plant has been evaluated several times by several groups. A project to improve the plant is underway An additional review or evaluation to identify best management practices is probably not necessary; however, current management and monitoring procedures should adhere to HACCP principles. In other words, management practices should be outlined with critical limits, monitoring procedures to test critical limits, corrective actions and recordkeeping.

Figure 5: Management Areas for Controlling Biological Hazards in the Alameda Watershed



It should be recognized that in this HACCP-based water quality plan, the best management practices for each management area are recommended without prior testing. While they are widely accepted, and effective range management and wildlife management practices, their effectiveness for protecting water sources from *Cryptosporidium* and other waterborne contaminants is not proven. Scientific research usually is presented in terms of statistical reliability --what percentage of similar treatments will yield results within certain parameters of reliability. These statistics are developed after measuring the treatment results a sufficient number of times to determine what the percentages and parameters are. In managing biological systems,

like watersheds we expect variation in the results, and until further assessment and monitoring is conducted we can not quantify that variation in advance.

Wildlife systems, in particular, can be expected to vary widely in their response to treatment For example, drought or long cold periods in one year can kill many pigs, and render unnecessary the removal you might have done just prior. On the other hand, a year of mild climates and good acorn production can stimulate pig production to the extent that the control measures are more than overcome by the pig population. This inherent variability demands certain accommodations and understanding of the predicted results of the HACCP process.

First, the HACCP process will often be in a reactive mode rather than a preventive mode. It will not be always possible to detect wild biological problems before they exist. Once they exist, they can cause problems in the water supply until they are detected and overcome. This is true in every biological system and in every watershed.

Second, in order to minimize the amount of time during which the biological problems exist, it is necessary to have a permanent, at least annual, monitoring program with adequate financial provision for follow-up control whenever problems or potential problems are detected. The importance of monitoring for evaluating and adjusting current best management practices and for identifying additional hazards and best management practices can not be overstated.

Third, no matter how well the monitoring and control procedures are done, there will be times when one or the other will be overdone or underdone. There is no fiscally reasonable way to avoid this problem. In some cases, it will not be possible to avoid even without any fiscal restraints.

Alameda Watershed
Biological Hazards Control Program

Watershed Water Quality - Pathogen Monitoring Protocol

The best management practices (BMPs) described in this plan should eliminate the potential risk from cattle contaminating source water with *C. parvum* and should significantly reduce the risk from feral pigs and other mammalian sources contaminating source water. However, only through a comprehensive monitoring program can the San Francisco Water Department clearly identify potential sources of these protozoa and assure water users that the BMPs implemented to guard against *C. parvum* and other waterborne pathogens are indeed effective.

Monitoring fecal samples from selected mammalian populations in conjunction with strategic water testing will allow the Department to identify hazards, implement control strategies, and confirm that source water is being protected under the designated plan. Fecal testing allows the rapid identification of mammalian populations and specific age groups that shed these parasites. If a population of animals fail to shed these protozoal parasites, they do not represent a hazard. If a population of animals are shown to be infected with these parasites, then the conditions that allow for contamination of source water must be present. Prevent one or more of these necessary conditions and you prevent adulteration of source water.

Monitoring of selected sources of water at strategic sites and during specific seasons, in conjunction with fecal testing of livestock and wildlife, will allow the S.F. Water Department to maximize the likelihood of detecting contamination events and therefore optimize their control programs if deficiencies are found. For example, previous monitoring on the watershed has involved the testing of stockponds to indicate whether cattle could contaminate a standing body of water when allowed unrestricted access. Such monitoring was conducted during the winter months, a time when the calves had exceeded the age at which they were most likely to shed *C. parvum*. The sensitivity of monitoring stockponds for *C. parvum* would be increased if such monitoring was conducted during a time when the annual calf crop was 1-3 months instead of 4-6 months of age. It should be noted that the methods for water sampling of *Cryptosporidium* have problems with recovery rates, accuracy and are expensive. It is costly to sample a large number and difficult to draw conclusions or make comparisons. Therefore, it is very important that water sampling be conducted at strategic sites in concert with fecal monitoring.

Another example of strategic monitoring would involve sampling of seasonal creeks that flow through grazed pastures when 1-3 month old calves are present, or during rainfall events of sufficient magnitude to generate overland flow. It is mandatory that water samples be taken both above and below the suspected source of parasites in order to make valid inferences. With respect to testing fecal samples from livestock and wildife, such testing, although laborious, provides exact site-specific information on which populations shed these parasites (cow-calf herds, feral pigs, California ground squirrels, etc.), prevalence and intensity of infection by these populations, and seasonal shedding patterns. A variety of laboratories can conduct this work, both within the University of California and in the private sector. Dr. Atwill's Environmental Animal Health Laboratory is willing and capable of conducting all necessary fecal tests for livestock and wildlife, but the expense of the procedure would

need to be covered Dr. Atwill, UC Davis, in collaboration with Drs. Paul Rochelle and Ric DeLeon, Metropolitan Water District of Southern California, are currently conducting a statewide project to molecular fingerprint isolates of *C. parvum* from livestock, wildlife, humans and water samples. Dr Atwill has consented to compare a set of isolates from positive fecal tests to any isolates obtained from water samples to help resolve the adulterating source of *C. parvum*.

With appropriate funding from S.F. Water Department or allied regulatory agencies (e.g., State Water Quality Control Board, CA EPA), Dr. Rob Atwill, School of Veterinary Medicine, Dr. Ken Tate, Department of Agronomy and Range Science, and Dr. Lee Fitzhugh, Department of Wildlife, Fish and Conservation Biology, University of California, Davis, are willing to assist in the design of the fecal and water monitoring program, assist in or help coordinate livestock and wildlife fecal sample acquisition, and assist in the statistical interpretation of the data. Pending approval by the S.F. Water Department, Drs. Atwill, Tate and Fitzhugh would work with the identified stakeholders and seek additional manpower resources from UC Cooperative Extension, California Department of Fish and Game, USDA Natural Resources Conservation Service and the Alameda County Resource Conservation District.

It may be tempting to forego the cost of implementing a comprehensive monitoring program; however, in addition to providing assurances to San Francisco water users, this monitoring program will be essential for documenting watershed management practices that can and will be applied on watershed lands beyond the boundaries of San Francisco owned lands San Francisco only owns about 30% of the Alameda watershed Implementing voluntary BMPs on neighboring privately and publicly owned lands in the watershed will require cooperation and a knowledge of scientifically sound BMPs.

Livestock Fecal Testing

Fecal samples from cow-calf herds will be collected from 40-50 calves and 40-50 cows to monitor their shedding status of *C. parvum* and *G. duodenalis*. The samples will be collected twice annually; once when the majority of the calves are less than 4 months of age, and once after the majority of the calves are 4 months of age but prior to weaning.

The monitored cow-calf herds will be selected so that they are grazing in different sub-watersheds. At a minimum, one herd will be grazing adjacent to a major tributary to Calaveras Reservoir, Upper Alameda Creek above the diversion dam. Another herd will be grazing along a smaller feeder stream, Calaveras creek. These locations were selected because Upper Alameda Creek has a USGS gauging station to monitor stream flow, and within the subwatershed of Calaveras creek there is known to be an active feral pig population. Correlating *C. parvum* concentrations to stream flow provides some information regarding the transport mechanism (i.e. storm runoff versus direct deposition) Pending financial resources, additional herds should be included in the fecal monitoring in order to clearly identify the seasonal trends in shedding for the cattle herds on the watershed. We would encourage the acquisition of site-specific data on cattle fecal shedding rather than to rely on literature reviews given the importance of protecting this watershed.

Wildlife Fecal Testing

Part 1: A thorough survey of wildlife fecal pellets (scat) will be collected from each sub-watershed in the early fall of 1997 and tested for *C. parvum* and *G. duodenalis*. The species of each fecal sample will

be tentatively identified. Scat surveys will be focused near watering sources, riparian habitat, and concentrated feeding locations in the sub-watersheds. This survey will be conducted prior to the cattle calving season in order to identify which, if any, wildlife species are potentially seeding the watershed with *C. parvum* and *G. duodenalis*.

Part 2: Guided by information obtained in part 1, a wildlife trapping program will be implemented to collect rodent fecal material every other month for 8 months to further clarify reservoirs of *C. parvum* and *G. duodenalis*. Trapping will be focused near watering sources, riparian habitat, and concentrated feeding locations.

Fecal samples from elk will be collected by observing them while bedded and collecting samples from the area when they vacate. This procedure allows a minimum of intrusion on the elk herd and a large number of samples to be collected. Fecal samples from deer will be obtained by observing them in the open until they defecate, marking the spot, and then retrieving the sample. This procedure, as with elk, allows a minimum of intrusion and a large number of samples to be collected. Fecal samples from dispatched feral pigs will be collected per rectum.

Water Quality Monitoring- Livestock / Wildlife Water Sources

In conjunction with wildlife and cattle fecal testing, concentration of *C. parvum* oocysts in the primary water supplies available to calves in the sub-watershed will be measured. The ICR method will be used, and percent recovery will be validated using seeded water samples. Dr. Atwill has ready access to large numbers of oocysts and can assist S.F. Water Department in constructing positive water controls for exact measurement of the ICR method's percent recovery for site-specific water supplies. Sampling water sources can help to determine the route in which transmission of *C. parvum* is occurring. It has been hypothesized that the initial route of transmission of *C. parvum* between wildlife and rangeland calves may be via calf drinking water contaminated with wildlife feces. If wildife are the reservoir of *C. parvum* for livestock, breaking this route of transmission may reduce the percentage of calves acquiring this parasite and therefore reduce environmental loading and subsequent risk to water.

Water Quality Monitoring- Above and Below Potential Sources

In order to assure the effectiveness of BMPs and to quantify the relative contributions of protozoal contaminants (if any) from livestock, wildlife and human sources, water samples from creeks and streams flowing into reservoirs will collected above and below selected areas of concern. Monitoring of creeks and streams entering reservoirs has been lacking. The quality of water entering the reservoirs needs to be established and could pinpoint sources of contamination. These selected areas of concern will be identified primarily by the location of mammalian populations that have been confirmed to have positive fecal tests for these protozoa. Mammalian populations found not to be infected with these parasites are unlikely to serve as significant sources of the parasites. In regards to damole design, timing is very important. Water samples will be collected and tested every month from the designated above and below sites and twice annually during peak flow events. Above and below water sampling is an valid method to monitor cause and effect (Spooner et al 1985).

Livestock. In order to insure that livestock are not contaminating source water with *C. parvum* and *G. duodenalis*, water samples will be collected where the Upper Alameda Creek and the Calaveras Creek enter and exit the grazed section. Such sampling should at a minimum be conducted when young

calves are in the herd and during rainfall events of sufficient magnitude to create overland flow. Pending financial resources, additional monitoring should be conducted monthly on a set of stockponds for 4 months following calving in order to determine whether cattle can contaminate a standing body of water when allowed unrestricted access. If *C. parvum* and *G. duodenalis* are not detected in these high use areas, it would suggest that non-point source protozoal contamination of source water from gazing cattle is considerably more difficult than currently thought.

Wildlife. To test for potential contributions from wildlife, above and below monitoring will be conducted on the Arroyo Hondo creek, and above and below on a feeder stream. Arroyo Hondo and the designated feeder stream are within sub-watersheds that have little to no potential contamination from livestock. Arroyo Hondo has a USGS gauging station to monitor flow.

Human Recreation. To test potential contributions from humans, above and below monitoring will be conducted along the lower reach of Alameda Creek where it runs through East Bay Regional Park Lands. Although there is livestock grazing in this sub-watershed, there may be significant contributions of water contaminants from human and pet recreational users in the park.

As mentioned previously, at the discretion of the Department, positive water samples may be included in a current study to molecular fingerprint *Cryptosporidium parvum* isolates.

Applying Monitoring Data

This monitoring information will be essential for completing HACCP (Hazard Analysis Critical Control Points) for addressing potential biological hazards in the Alameda Watershed. Not only will this data assure that currently recommended BMPs are effective, but it will also provide information to establish additional BMPs and monitoring, set critical limits, and prescribe corrective actions.

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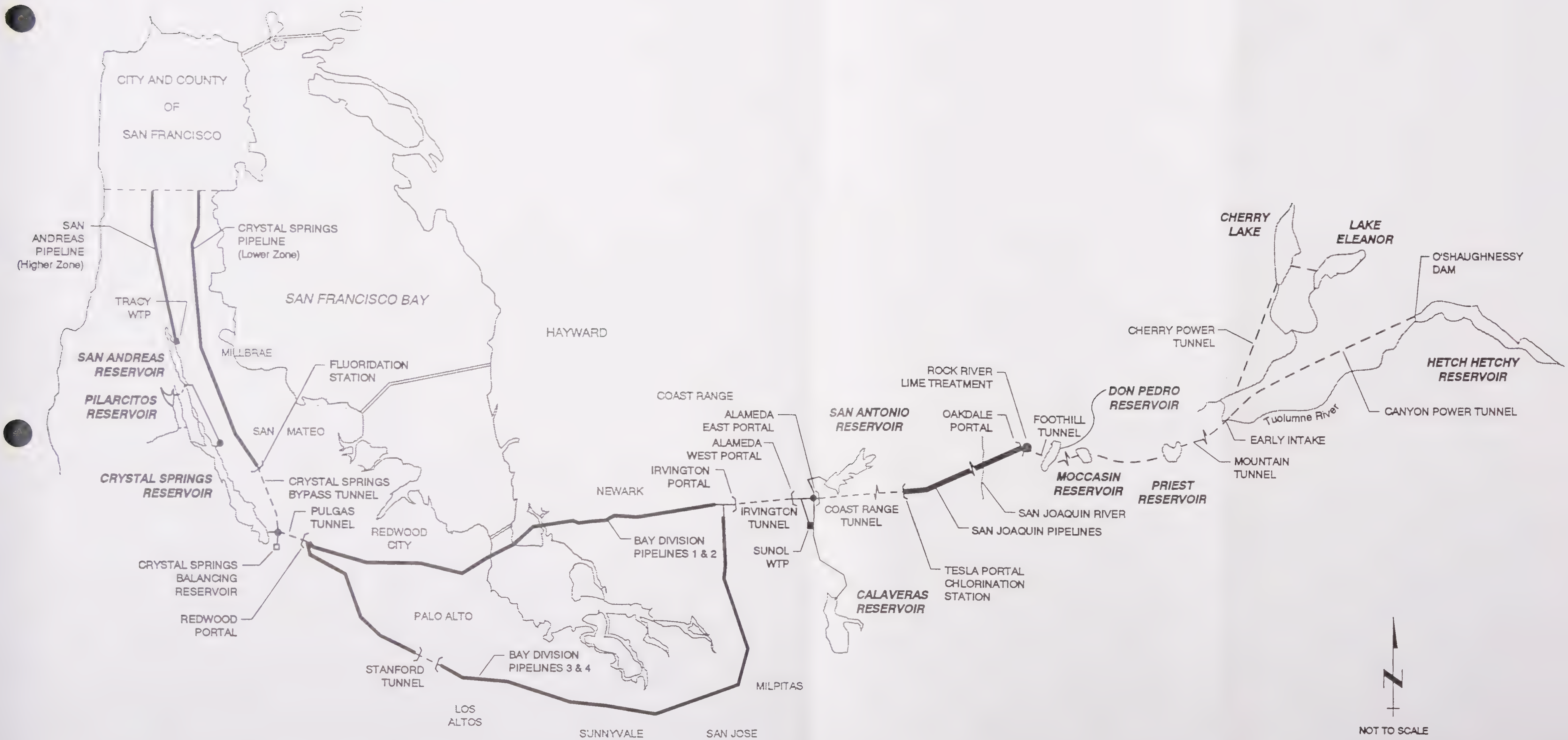

OVERVIEW OF SAN FRANCISCO WATER SYSTEM

FIGURE 2

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*Note: Sunol Drainage Unit modified to exclude Sinbad & Vallecitos Creeks

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ALAMEDA CREEK WATERSHED

FIGURE 3

Alameda Watershed Biological Hazards Control Program

Livestock- Grazing Management

Hazard: Cattle contaminating source water with *Cryptosporidium* and *Giardia.*

Risk Assessment:

Cattle, similar to a wide variety of domestic, feral and wild mammals, including humans, have been found to shed *Cryptosporidium parvum* oocysts and *Giardia duodenalis* cysts, but there is no scientific evidence supporting the claim that cattle are the primary environmental source of *C. parvum* or *G. duodenalis* for California surface water. Concentrations of *Cryptosporidium* oocysts and *Giardia* cysts have been detected in pristine surface water, where there are no cattle or other domestic livestock in the watershed (Madore et al. 1987). An accurate risk assessment regarding cattle grazing and water quality requires knowledge of the age-associated prevalence of cattle shedding these protozoa, the survivability of protozoal oocysts/cysts on rangeland and in water, and the likelihood that viable protozoal oocysts within fecal patties can reach bodies of surface water during conditions of rainfall and overland flow.

Over the past two years several University of California research projects have been devoted to assessing the link between rangeland cow-calf production and concentrations of viable *C. parvum* oocysts and *G. duodenalis* cysts within associated surface water. These research projects are collaborative in nature due to the complexity of the issue, involving veterinary medicine, range ecology, water quality, environmental microbiology, and molecular biology. Although much of the research is still underway, preliminary research findings provide guidance for identifying livestock and grazing management practices that can significantly minimize potential risk from cattle contaminating surface water with *C. parvum* or *G. duodenalis*.

The research has clearly indicated that the greatest risk from cattle contaminating source water occurs if <u>infected</u> cattle directly deposit fecal matter in source water. Excluding potentially infected cattle, like young calves, from direct contact with source water may eliminate almost all of the risk associated with cattle contaminating surface water with *C. parvum* or *G. duodenalis*.

<u>Age-associated prevalence of cattle shedding protozoas.</u>
A University of California statewide epidemiological study examined the prevalence of and risk factors for shedding *C. parvum* and *G. duodenalis* in rangeland cow-calf herds. Thirty-eight herds and around 1400 cattle were enrolled in the study. Researchers found that shedding of *C. parvum* in cow-calf herds is primarily limited to calves under 4 months of age. Watershed management practices attempting to reduce the risk of cattle contributing *C. parvum* to waterbodies should focus on young calves.

In addition, given that calves are presumed to develop a sterile immunity to cryptosporidiosis in 10-20 days, it is unclear how a seasonally calving herd becomes reinfected each year. A specific U.C. research project has been initiated to determine whether the precalving-cow is the reservoir of infection or whether some other environmental source is responsible. Thus, the potential role of wildlife in contaminating surface water and serving as a reservoir of infection should not be overlooked.

Survivability of protozoal oocysts on rangeland and in water.

If protozoal oocysts are shed in feces on rangeland, they can only contaminate source water and pose a potential risk to human health if they remain viable in the manure until they can be transported via overland or subsurface water flow to nearby source water. *Cryptosporidium* oocysts that dry-out become non-infective in just a few hours. If fecal material thoroughly dries before reaching water, the oocysts would presumably become non-infectious to other animals and humans (Anderson 1986; Robertson et al. 1992).

Oocysts shed directly into source water may remain viable for longer periods of time than those shed on rangeland. One study found that after 33 days in river water, 34% - 40% of purified oocysts became non-infective. After 176 days, 88% -99% of the oocysts had become non-infective (Robertson et al. 1992).

The likelihood of viable protozoal oocysts within fecal patties reaching source water during conditions of rainfall and overland flow.

A comprehensive U.C. research project is underway which is examining the underlying mechanics of how oocysts move across and move through soil during conditions of rainfall. This project is evaluating how wide a riparian grass buffer strip is needed to filter out these protozoal eggs during conditions of overland flow. This is a critical question when faced with the decision of how far back from a reservoir or river should a fence be placed in order to protect water quality, or is a fence even necessary.

Buffer strips have been shown to provide significant reduction in transport of sediment, nutrients, and bacteria. Glenne (1984) looked at a model which simulated the generation of water pollution in three watersheds in northern Utah. He noted that a buffer strip approximately 50 meters wide is needed to reduce bacterial concentrations by 90% on a 10% slope, and 90 meters wide on a 20% slope. Bingham et al. (1980) studied buffer strips in relation to sediment control including phosphorus and nitrogen from poultry waste spread across open fields. They concluded that the buffer strips needed to be as wide as the spread width of manure, i.e. if manure was spread 13 meters wide, at least 13 meters of a buffer strip was necessary.

Because evaluating the mechanism of transport involves consideration of numerous variables including source, soil type and permeability, slope, vegetation cover, and rainfall intensity and duration, establishing an appropriate width for a buffer strip must be site and objective specific. In regards to establishing an effective buffer to guard against the transport of fecal contaminants deposited on rangeland environments from free grazing cattle more information is needed. Larsen et al. (1994) monitored runoff from fresh cattle feces placed on grass sod buffer strips and subjected to simulated rainfall. They found that the number of bacteria was reduced by 83%

during a 30-minute simulated rainfall event when the collection point was placed 0.61 m from the manure. Bacterial loads were reduced by 95% if 2.13 m of separation between the feces and the collection point was maintained.

Unlike *C. parvum* in which there is unequivocal evidence for its ability to be transmitted from one species to another, considerable controversy surrounds the issue of whether *G. duodenalis* cysts obtained from livestock can infect humans. Upon reviewing the existing scientific literature with respect to transmission of *G. duodenalis* cysts from livestock to humans via water, Thompson and Boreham, 1994 and Erlandsen, 1994 both concluded that convincing data still does not exist. Finding such evidence remains severely constrained given our historically poor ability to identify the vertebrate source of waterborne *G. duodenalis* cysts (Thompson and Boreham, 1994).

Grazing Unit Plan:

Livestock grazing as a management tool can be utilized to manage open range for water quality, biodiversity, fire and other factors. Unmanaged livestock grazing especially around sensitive areas including streams, springs, seeps and steeply sloping areas can result in soil erosion, sedimentation, loss of wildlife habitat and risk to water quality of nearby surface waters. A watershed management plan that uses grazing as a management tool will utilize the topography, rainfall, soil type and existing vegetative ecosystem in a defined management area to balance appropriate levels of grazing, describe animal movement through the pastures and allow for protection, enhancement and restoration of specific ecosystem functions.

The first element to any grazing/livestock plan should be to define management areas. Typically management areas will be defined by fencelines. Location of management areas should not be based on existing fencelines but on resource objectives and application of livestock as management tool to achieve those objectives. San Francisco Water Department watershed managers should work with local biologists, livestock owners/ managers, lessees and neighboring landowners in the Alameda watershed to define management areas. Aerial photos and/or maps, including GIS maps showing terrain, vegetation and water sources can be used to develop effective management areas. The following criteria should be followed when developing fencelines:

- The size of the pasture should facilitate management with controlled grazing.
- Irregular shapes should be avoided.
- Vegetation types included within a pasture should not impair uniform distribution.
- Fences should be established with the topography.
- Shape and location to facilitate the movement of livestock and wildlife.
- Location of water source must be considered.

Before the Livestock Management - Grazing critical control points can be implemented the grazing units and objectives for each grazing unit need to be defined (see Appendix I).

Critical Control Point 1: Minimize the intensity of infection in cattle.

Best Management Practices:
In consultation with their herd veterinarian, livestock owners/managers will establish a herd health program for the prevention and care of general parasitic diseases. At a minimum the herd health program will include the following measures to maintain healthy immune systems and minimize the occurrence of diarrheal infections: (1) routine vaccination of all cattle for preventing BVD (Bovine Virus Diarrhea) which can act as an immunosuppressive disease; (2) routine internal parasite control (deworming) to prevent clinical parasite infections; (3) prevention of selenium and copper deficiencies with appropriate supplementation depending on current herd status, (4) and avoid overcrowding during calving and subsequent grazing when young stock are present in order to minimize animal-to-animal transmission.

Herds should be closed to the introduction of outside suckling (neonatal) calves. Calves from outside the herd may introduce *C. parvum* or other pathogens to the herd.

Monitoring:
Trained ranch personnel will check cattle frequently for disease. Frequency of inspection will depend on herd's reproductive and current health status.

See " **Watershed Water Quality - Pathogen Monitoring Protocol".** The prevalence of *C. parvum* and *G. duodenalis* will be monitored in selected herds, such as herds that have access to seasonal creeks that eventually feed into either reservoir. When appropriate, the concentration of *C. parvum* and *G. duodenalis* in surface water sources both above and below these herds will be measured in order to determine if and under what conditions (climatic, environmental) do cattle inadvertently elevate associated bodies of water with these protozoa.

Critical Limits:
Corrective action should be implemented when clinical disease is observed.

Corrective Action:
Cattle exhibiting clinical disease should be promptly treated. A veterinarian should be consulted as necessary.

Record Keeping: Livestock owners/managers will keep herd health records as follows.

- Records (product, dose, animal id, employee id) of vaccinations and routine procedures of groups of cattle.

- Records of treatment disease protocols (diagnosis, product used, dose) or individual treatment records (diagnosis, product used, dose, injection method, date, employee).

Critical Control Point 2: Control cattle grazing and access to reservoir and riparian areas with fencing.

Best Management Practices: Develop and maintain reservoir and riparian pastures (buffers) around reservoirs and streams with riparian habitat. Riparian habitat with SFWD lands has been mapped during the Watershed Management Planning Process. To minimize potential water quality risks, reservoir and riparian pastures should be non-calf and non-corral pastures. These pastures should be designed to be grazed or otherwise managed. Management practices including grazing management (season of use, stock rate, and frequency of grazing) will depend on specific resource objectives for each pasture.

Before new fences are built, current livestock owners/managers and San Francisco Water Department watershed managers should complete a grazing unit plan.

Monitoring:
Barrier fences to reservoirs or riparian area will be checked weekly by livestock owners/managers and SFWD watershed keepers.

(Riparian / reservoir pastures should be monitored based on objectives identified in the grazing unit plans. Annual monitoring could include riparian photos, bioassessment, riparian inventory, measuring stream channel morphology and mapping utilization and residual dry matter. Critical limits and corrective actions will depend clearly and specifically identifying objectives for the riparian / reservoir pastures.)

Critical Limits:

Corrective action should be implemented if fence is broken or breached.

Corrective Action:

Fence should be promptly fixed. If watershed keepers discover the fence is breached or broken they will immediately contact the appropriate livestock owner/ manager. Cattle breaching fenceline should be immediately moved to the appropriate pasture.

Record Keeping:

Livestock owners/managers and watershed keepers will record, date, situation (including type and number of animals involved), and actions taken to correct any breach or disrepair of reservoir pasture or riparian pasture fences.

Critical Control Point 3: Manage residual dry matter (RDM) to reduce fire hazard and minimize potential for feces transport (minimizing runoff) by controlling grazing utilization and distribution

Best Management Practices:

Good even distribution of livestock utilization and fecal material is essential for minimizing potential water quality problem. In particular, livestock distribution is the key to decreasing feces deposited near water, reducing transport of fecal material by overland flow, and maximizing fire protection.

Managing residual dry matter (RDM) on an annual range site is the most effective way to monitor and manage for even distribution of livestock utilization. Managing for RDM also a range managers' means of influencing soil surface condition and ultimately soil infiltration capacity, water holding capacity, and plant productivity. Sufficient RDM can minimize runoff and the potential for fecal transport, as well as minimize soil erosion. Appropriate levels of RDM need to be left on range sites after growing season and prior to fall rains to reduce fire hazard and minimize erosion. USDA Natural Resource Conservation Service site specific recommendations for SFWD lands based on soil, climate, and vegetation indicate that 700 to 1000 lbs of residual dry matter should be left to minimize runoff and protect soils from fall rains as well as maintain productivity for most soils and slopes in the Alameda watershed (USDA, 1966). During the Grazing Unit Planning process specific RDM target levels may be set for each grazing site based on resource objectives.

Managing grazing livestock to achieve a target RDM of 700 -100 lbs will require appropriate stocking rates, as well as controlled livestock distribution. Controlled grazing is planning-monitoring-controlling-replanning. Stocking rates refer to the amount of land area allocated to each animal unit for the entire grazing period in one year. The stocking rate varies between years due to weather and previous use Grazing units should be stocked at rates so that target RDM levels can be reached in most years. Livestock owners/ managers should be prepared to move livestock early in drought periods

Monitoring: Identify likely or suspected areas of different use by marking use zones on a map for each grazing unit A specific grazing unit may consist of a single ecotype or vegetation type, but due to variation in the site, monitoring should evaluate the site by several use zones. Factors that influence wildlife / livestock use should be mapped. This could include topography, water sources, soil and vegetation types. Fences, corrals, gates, shade and roads may also dictate utilization zones of range. The distance and location of these features in respect to each other will be considered when determining zones. The items should all be identified on a map.

Measure RDM at the end of the growing season and record on the grazing unit map A double sampling method is recommended for determining RDM The double sampling method will provide for accurate information for decision making regarding watershed/ resource management Visual-only estimates of RDM are usually not very accurate.

The double sampling procedure involves making a visual estimate of RDM in a specific area, followed by clipping and weighing the same area. After repeating this procedure, usually about 10 paired samples are sufficient, the data collector is "trained" and can visually estimate a large number of specific areas. At the end of the visual-only estimating session, a second collection of paired plots are collected. The two paired sample collections are used to make a "correction factor". Details on paired sampling monitoring and a computer program to assist with calculations can be found in "How to" Monitor Rangeland Resources.

RDM monitoring information collected at the end of the growing season can be used to determine if there is adequate forage to last through the grazing season or if livestock numbers should be reduced.

Recording RDM levels on a grazing unit map will help to determine areas of under or overutilization. This information can be used to improve livestock distribution. RDM data can be summarized by utilization class (light, moderate, heavy) and graphed. This summary should provide information to evaluate stocking rates and livestock distribution.

Critical limit:

Corrective actions should be implemented relative to location of utilization zones with light or heavy use. If heavy use zones are identified in areas adjacent to stream channels corrective actions to redistribute livestock must be considered. Corrective actions for livestock distribution should also be implemented if light use zones are noted in areas of severe fire hazards. Fire severity area have been mapped in developing the watershed plan for the Alameda watershed.

Corrective actions to adjust stocking rates should be implemented if target levels are reached after the growing season ends and before the end of the grazing season.

Corrective Action:.

Livestock owners/ managers must be consulted in developing corrective actions to effectively manage RDM levels for specific grazing unit objectives.

Stocking Rate

The grazing season will end once target RDM levels are reached. If under typically environmental conditions target levels are reached during the growing season, base stocking rates should be reduced in subsequent years. If target levels are not reached during the grazing season, base stocking rates should be increased. Stocking rates must remain flexible to account for year to year precipitation and forage growth variability.

Livestock Distribution

Among the easiest tools to use in managing livestock distribution are salt/mineral, water, herding and supplemental feed. Moving salt/mineral feeding locations away from water is one way of improving livestock distribution. Traditionally, people have thought that cattle must have water after consuming salt. Recent information indicated that cattle do not utilize salt or mineral and then water or vice versa. Distributing livestock with the placement of supplemental feed is also an effective tool for managing livestock distribution. Herding is frequently used by livestock owners/managers on San Francisco PUC lands to improve distribution.

Although developing water is one of the more expensive tools to manage livestock distribution, it is also one of the most effective tools. Recently several springs have been developed by livestock owners/managers grazing on San Francisco PUC lands to improve livestock distribution. To be effective water should be located so that cattle do not have to travel more than ½ to ¾ mile in the hilly topography of the Alameda watershed to drink.

Additional fencing may also be needed to solve livestock distribution problems where the above methods prove ineffective.

Record Keeping:

Livestock owners/ managers will record stocking rates, including in-out date, livestock numbers and class of livestock.

SFWD will keep monthly weather records, including amount of precipitation, and temperature (average, maximum, minimum).

Grazing unit utilization maps will be updated annually.

Critical Control Point 4: Strategically locate areas of livestock concentration.

Best Management Practices:
Both livestock and wild game will concentrate around areas such as watering places or feeding grounds. These areas should be located so that they are hydrological remote and avoid any potential opportunity for concentrated waste to contaminate source water. For example, stock tanks, feed, supplements should not be located in stream channels, swales, or flood plains. In some locations, livestock should be excluded from stockponds and an alternative permanent water source provided.

This best management practice is in complete agreement with Control Point 3. In general, moving an attraction such as supplement feeders or water to improve livestock distribution will be moving an area of livestock concentration to a hydrologically remote location.

Handling facilities should not be located in flood plains.

Monitoring:

All potential areas of livestock concentration should be included on the grazing unit map.

Critical Limits:

Concentration areas should not be located or cause overutilization problems in areas of high water vulnerability, or in areas near source water.

Corrective Action:

Consult with livestock owners/ managers to relocate concentration areas to hydrologically remote locations.

Record Keeping:

Areas of heavy utilization should be mapped on grazing unit utilization maps.

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Alameda Watershed
Biological Hazards Control Program

Wildlife Management - Feral Pigs

Hazard: Feral pigs contaminating source water with *Cryptosporidium parvum* and *Giardia.*

Risk Assessment:

Feral pigs are abundant in western California and data collected in the summer of 1995 suggest that feral pigs may contaminate nearby surface water with *Cryptosporidium parvum* and *Giardia duodenalis*. In particular, feral pigs focus activities (wallowing and foraging) around the margins of seeps, springs, ponds, streams and lakes during the summer months. Feral pigs in the Alameda watershed have direct access and can deposit fecal material directly into the reservoirs and perennial streams. Sweitzer et al (1997) found that 5% and 8% of all feral pigs sampled during the summer were shedding *C. parvum* oocysts and *G. duodenalis* cysts, respectively. Age-associated shedding of *C. parvum* was 11% for feral pigs less than or equal to 8 months of age and on average 3% for feral pigs older than 8 months of age. Although we do not know the zoonotic potential for *C. parvum* oocysts and *G. duodenalis* cysts shed by feral pigs in California, it is likely that both the oocysts and cysts shed by this population would cross-react with the ICR procedure in use for monitoring water for these pathogens.

In the study by Sweitzer et al (1997), shedding of *C. parvum* by feral pigs was strongly associated with measures of population density. No pigs from low density populations were shedding *C. parvum*, compared to 9 -10 % in populations with 2.0 pigs per square kilometer or greater. The odds of shedding *C. parvum* was 4 times greater for feral pigs less than or equal to 8 months of age compared to older pigs. Wild pigs reproduce year round. Pig populations around Calaveras Reservoir are currently considered to be high density. In July 1995 the SFWD in cooperation with the Department of Fish and Game and the East Bay Regional Park District began a program to control feral pigs. The program was suspended in May 1996 but over 350 pigs were removed. It is estimated that there may be 1000 feral pigs in the Alameda Watershed.

Although the overall proportion of wild pigs shedding *G. duodenalis* compared to *C. parvum* was similar for pig populations tested, the associated risk factors for shedding were very different for the two protozoa. For *C. parvum* shedding, pig age and population density were strong risk factors; however, there was no clear association between *G. duodenalis* shedding risk for feral pigs and demographic or environmental variables

Critical Control Point 1: Minimize the population and infection rate of feral pigs.

Best Management Practices:

The risk of environmental contamination of *C. parvum* from high density pig populations is two-fold: more wild pigs per unit area are serving as a potential reservoir of *C. parvum*, and a higher percentage of pigs are shedding the parasite. Therefore, pig densities should be reduced with a persistent, flexible control program. The control program could include the following:

- Trapping pigs with box or corral type traps during dry or summer months. To increase the success of trapping, trap sites should be selected based on recent pig activity. Potential trap sites and traps should be pre-baited.
- Hunting with trained pig hounds in the winter and spring.
- Intensive and continual hunting at selected sites. Hunting by police officers working with the local State Fish and Game warden have nearly eliminated feral pig populations in the Hastings Natural Reserve in Monterey County.

Monitoring:

Wild pig populations will be monitored in the late spring along transects that survey for pig activity near source water including riparian habitat.

See " **Watershed Water Quality - Pathogen Monitoring Protocol".** Fecal samples from pigs trapped and dispatched will be analyzed for the presence of *C. parvum* and *G. duodenalis*. When appropriate, water quality above and below areas of concentrated wildlife activity will also be monitored.

Critical Limit:

Because the goal of controlling the pig population is to minimize risk of pigs contaminating source water, control programs should continue as long as pig activity is detected near source water including riparian habitats. (In addition to potentially contaminating water with pathogens, wild pigs can also accelerate erosion processes in a watershed. Refer to section: Alameda Watershed - Physical Contaminants).

If a persistent, flexible pig population control program becomes unfeasible because of legal, social or other reasons, alternative corrective action should be considered.

Corrective Action:

Strategic fencing to exclude pigs from reservoirs and riparian areas. Pigs may be excluded from small areas with a strong wire mesh fencing, fastened tightly to the ground or buried for its complete extent. The effectiveness of the fence may be enhanced by adding an electrified wire on the outside, which will keep pigs from trying to burrow under. Excluding pigs with strategic fencing from an extensive area would be an on-going challenge.

Record Keeping:

Record location, method, date, age, results of fecal analysis of trapped and dispatched pigs. Record survey results from semi-annual pig activity survey.

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Alameda Watershed
Biological Hazards Control Program

Wildlife Management - Further Assessments

Hazard : Wildlife contaminating source water with *Cryptosporidium* and *Giardia.*

Risk Assessments:

Little is known about the prevalence of shedding *Cryptosporidium parvum* among wildlife species with access to surface waters. However, shedding of *C. parvum* has been confirmed in eighty species of mammals. Given that concentrations of *Cryptosporidium* oocysts ranging from 0.005 - 18 oocysts / liter, have been detected in pristine surface water (within watersheds with no domestic livestock and limited human activity), the role of wildlife in contaminating surface water with these protozoa should be carefully examined (Madore et al. 1987).

Similar to *C. parvum, Giardia duodenalis* is commonly shed by a wide variety of wildlife species. It has not been determined which vertebrate species, including humans and livestock, are the primary sources of *G. duodenalis* for surface water in California.

To determine the need for controlling various species of wildlife, assessment of prevalence of *C. parvum* and *G. duodenalis* among various wildlife species should be conducted. Species to be considered as potential sources of waterborne pathogens in the Alameda Watershed include: deer, elk, coyotes, ground squirrels, mice, voles, gophers, and wood rats.

Risk associated with rodents.
It has been hypothesized that a likely candidate for a wildlife reservoir of *C. parvum* could be a ubiquitous rangeland species, such as the California ground squirrel (*Spermophilus beecheyi*) or other such rodent. Gray squirrels are known to shed this pathogen (Sundberg et al. 1982) and *Cryptosporidium* oocysts from wild mice (*Mus musculus*) have been shown to be infectious to calves (Klesius et al. 1986). Sixty three percent (46/73) of wild brown rats (*Rattus norvegicus*) were shedding *C. parvum* in one study (Webster et al. 1995). Cryptosporidiosis has been reported in the eastern cottontail (*Sylvilagus floridanus*). In fall 1996, the Federation of American Scientist reported that a pathologist confirmed *Cryptosporidium* was the causative agent in the death of 15 baby squirrels, indicating that *Cryptosporidium* can replicate in squirrels.

Since *Cryptosporidium* seems to be sensitive to heat and desiccation, rodent fecal material scattered on the surface may not present a significant public health problem during much of the year. However, defectoriums (defecating sites) in covered nests or burrow systems could be a problem if they were flushed into the water during storm events. Gopher and ground squirrel burrows are known to serve as macropores or "pipes" for runoff water when one opening is located to receive surface flow, and interconnected burrow outlets are lower in elevation.

Reviewed literature does not indicate whether the California ground squirrel (*Spermophilus beecheyi*) defecates in burrow systems. The Columbian ground squirrel (*Spermophilus columbianus*) (Young 1989) and the white-tailed prairie dog ((*Cynomys leucurus*) Cooke and Swiecki 1992) construct defectoria in burrow systems, so it is likely that the California ground squirrel does also. Assuming squirrels defecate in burrows, the risk associated with ground squirrels is dependent on whether they are infected with *Cryptosporidium* and the number of burrow systems likely to serve as pipes.

If squirrels are determined to be a potential source of contamination, squirrel control around source water could be implemented.

With woodrats, the risk is associated with the number of nests within a floodplain area and whether the rats carry *Cryptosporidium*. Wood rat nests located in a flood plain can become detached or destroyed, with materials floating downstream. Because many of the stream channels in the Alameda watershed are steep, the floodplain area available for nests is limited and the risk should be slight.

<u>Risks associated with elk and deer.</u>

Elk can shed *C. parvum*; however, they calve in the late spring (just prior to the dry season). Assuming that young elk are more likely to shed *C. parvum* oocysts than mature elk, risk of source water contamination from elk may be minimal. However, if mature elk shed either *C. parvum* or *G. duodenalis*, their potential for contaminating source water should not be overlooked, because not only do they have access to reservoirs and other source water, but they are known to wallow in shallow water. If elk were determined to be a significant potential source of contamination, elk-proof fencing could provide a barrier to source water, but at substantial cost.

Mule deer have been shown to shed *C. parvum* (Heuschele et al. 1986). Potential contributions of *C. parvum* and *G. duodenalis* from deer may be less than from elk. Although deer numbers in the watershed are probably greater than elk, deer do not congregate near water and do not socialize in herds like elk. The elk herd resides within the Calaveras reservoir watershed. The deer are distributed throughout the Alameda watershed. Since deer are widely distributed and they have direct access to source water, an effort should be made to determine their prevalence for shedding protozoa. Like elk, deer fawn in the late spring, just prior to the dry season. Cryptosporidial infection has been confirmed in a variety of neonatal (young) captive deer.

<u>Risks associated with waterfowl, fish and amphibians</u>

Although waterfowl, fish and amphibians are not known to be infected by *C. parvum*, they can be the source of other species of *Cryptosporidium* which can cross-react with the ICR procedure for monitoring water for *Cryptosporidium*. Current water tests to determine the presence of *Cryptosporidium* can not differentiate species of *Cryptosporidium*. There are at least eight species of *Cryptosporidium*; however only one species has been found to be infectious to humans, *C. parvum*. It is possible that a positive water test for *Cryptosporidium* has detected oocysts that have no implication with regards to human health. These oocysts can be shed by a variety of wildlife including amphibians, fish, and birds. The presence of waterfowl, fish and amphibians

should be considered when interpreting results of a positive water test. Research is underway to develop a water test that can differentiate between the various species of *Cryptosporidium*.

In addition to creating a false positive water test, waterfowl could be responsible for transporting *C. parvum* oocysts from a fecal source to a water source via their digestive systems or their feet. If further assessments of wildlife as described in the Watershed Water Quality - Pathogen Monitoring Protocol are not able to provide satisfactory information regarding potential *Cryptosporidium* sources or if further efforts to reduce water quality risks are necessary, assessing waterfowl for prevalence of pathogens should be considered. A large number of waterfowl such as gulls and other shorebirds are often found on the reservoirs. Gulls in particular may create a risk because they may feed in nearby landfills providing the opportunity for a human - gull - human cycle. In addition, gulls could be responsible for contaminating water with other pathogens. Gulls can be discouraged from landing in the reservoirs with piano wire. Piano wire is placed 6 to 8 feet, across reservoir about 10 feet above the water. Shorebirds which feed in the shallow water at the reservoir edge could also present a potential pathogen problem. Shorebirds can be discouraged from feeding around the reservoir by making the sides steeper.

Further Assessment of Risks from Wildlife

Method for further assessing risks from wildlife are described in "**Watershed Water Quality - Pathogen Monitoring Protocol".**

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Alameda Watershed
Biological Hazards Control Program

Human- Recreation Management

Hazard: Humans and/or companion animals contaminating source water with *Cryptosporidium* and *Giardia*.

Risk Assessment:

Human waste including treated effluent may contain *Cryptosporidium parvum* and other pathogens. Recent tests on treated effluent from California's central valley detected 150 to 550 oocysts/liter. There are numerous sewage facilities located at the watershed cottages, at water system operations facilities, and at recreational sites. The sanitation facilities appear to pose a low risk to the reservoir and creeks water quality because they are either sewage vaults or chemical toilets and they are pumped out frequently. However, there is also a risk associated with an accidental spill from a waste tanker as it travels through the watershed (Watershed Sanitary Survey, 1995).

There are scattered rural residential areas on septic systems throughout the watershed. According to the Santa Clara County Department of Public Health and the University of California at Santa Crux- Environmental Health and Safety Office, there are approximately 110 registered septic systems in the watershed. These numbers may be low because the county began registering systems in 1955 and has no record of previously built systems. There has not been a significant problem with system failures, but as areas continue to develop with low density housing the risk of effluent contamination from system failure rises (Watershed Sanitary Survey, 1995)

The Sunol Valley Golf Course has a small wastewater treatment facility for the estimated 88,400 annual golf course users. The treatment facility handles flows of about 12,000 gallons per day from the golf course facility. Treated effluent is stored in a holding pond with a 30-day capacity. Wildlife drinking from the may have the opportunity to become infected with *Cryptosporidium parvum*. The treated effluent is diluted with irrigation water from Alameda Creek and used to irrigate the golf course grounds. Testing the treated effluent as well as runoff from the golf course would assess possible risks of Cryptosporidium contamination from this source.

Recreation within the watershed is restricted to lands owned and leased by the East Bay Regional Park District (EBRPD) and the Sunol Valley Golf Course. Other informal recreational activities occur throughout the watershed on land that is not owned by the San Francisco Water Department. These activities may include hunting on private land and recreational use in Joseph D. Grant County Park, in Santa Clara County.

Recreational activities at the Sunol and Ohlone Wilderness, operated by EBRPD include picnic and overnight backpacking facilities (including group facilities), extensive pedestrian, equestrian, and bicycle trails. There are also naturalist-led weekend programs and special events including a wilderness fair and running races. Approximately 200,000 persons per year use the park.

Much of the park activities occurs below the Alameda Diversion; however, water flowing in Alameda Creek through the park below the diversion can enter the water system at the Sunol Filter Galleries. The potential exists for humans, equestrians, or pets to contaminate water with microorganisms.

Prevalences of *C. parvum* shedding range from 0.1% to 27% (mean 4.9%) for human populations in industrialized countries, excluding AIDS patients and outbreaks investigations (Fayer et al 1997). A study by the San Bernardino County Department of Public Health Laboratory found that 2% (4/200) of the people who submitted fecal samples to the lab tested positive. Among the group of people at highest risk to be infected by *Cryptosporidium*, 30 to 60 % of Day Care Center attendees in several studies throughout the U.S. have tested positive. The risk associated with human activity is dependent on the ability of contaminated human fecal material to reach source water. According to EBRPD, less than 10% of the 200,000 people who use the park use the permanent toilet facilities. It is assumed that the remaining people use the chemical toilets or no facilities at all. Beyond not using a toilet facility, with such a large population using the park, one can think of unlimited ways that people could contaminate source water with microorganisms, i.e. rinsing off hands in the creek.

Dogs in the park may also present an opportunity to contaminate water. Fecal testing of 200 stray dogs in San Bernadino County revealed that 2% of the dogs were shedding *Cryptosporidium.*

Horses have also been examined as a possible source of *Cryptosporidium parvum*. Preliminary data from a state-wide horse survey indicates that less than 1 % of adult horses are shedding *Cryptosporidium*, and none of 311 horses located in the southern Sierras and used as commercial packstock were positive for this parasite. Finally, in a study sponsored by the Backcountry Horsemen of California, none of 91 horses with a recent history of being ridden in the backcountry were positive for *C. parvum* (Johnson et al 1997).

The risk to water quality from pathogens from humans and companion animals is probably minimal based on the prevalence of disease in the population and the opportunity for contaminated fecal material to reach surface water. A monitoring program described in the **"Watershed Monitoring Protocol"** section of this document would provide the opportunity to assess the significance of recreation in creating a biological water hazard.

Critical Control Point 1: Minimize the opportunity for human or companion animal waste to contaminate source water.

Best Management Practice

The key to minimizing the risk of humans or companion animals contaminating source water with microorganisms is education. Through pamphlets and signs, park visitors should be educated about the importance of water supplies, activities that can affect water quality, and measures to protect water quality. In addition, materials (i.e pooper scooper bags) can be provided encouraging people to clean up after their dogs.

Monitoring:

Park facilities operators should evaluate and monitor restroom facilities availability and location.

See " **Watershed Water Quality - Pathogen Monitoring Protocol.**" The potential contribution of waterborne pathogens from recreation use and sanitation facilities will be monitored by sampling water above and below recreational use sites.

Critical Limits:

Corrective Actions:

References:

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Alameda Watershed
Biological Hazards Control Program

Sunol Filter Treatment Plant Management

Hazard: Contaminated water at the Sunol Filter Treatment Plant

The Sunol Filter Treatment Plant has been evaluated several times by several groups. A project to improve the plant is underway. An additional review or evaluation to identify best management practices is probably not necessary; however, current management and monitoring procedures should adhere to HACCP principles. In other words, management practices should be outlined with critical limits, monitoring procedures to test critical limits, corrective actions and recordkeeping.

Alameda Watershed Biological Hazards Control Program

HACCP Verification System

Step 12

Apply Principle 7: Establish procedures to verify that the system is working consistently. An essential component of a HACCP-based program is a procedure to verify that the program is working correctly. Table 3 outlines the management and monitoring records that will be kept to validate the HACCP-based program to control biological hazards in the Alameda Watershed. Acknowledging that there are numerous stakeholders in the Alameda Watershed, including landowners, land users, and water users, an annual review of all records by an external review team is highly recommended. This team should be multidisciplinary, as well as representative of the variety of stakeholders and their interests. Representatives from the following groups are suggested to serve on the external review team:

San Francisco Water Users (individuals)
Bay Area Water Users (water districts)
East Bay Regional Park District
Department of Health Services
Alameda Watershed private landowners
SFWD land users (nurseries)
SFWD land users (grazing lessees)
Veterinarian
Certified Rangeland Manager
CA Department of Fish and Game

The external review team would be responsible for examining the records to verify that the HACCP-based water quality program is being implemented as outlined. They also will review records to determine if the program is being responsive to monitoring findings and new regulations. The review team should submit the results of their review to the San Francisco Public Utilities Commission, who would be responsible for taking actions on any recommendations made by the reviewers.

Table 3:
Management and Monitoring Records for Controlling Biological Hazards in the Alameda Watershed

Records	Recorder or Record Keeper	Period(s) of Recording
Watershed Monitoring		
Water Quality	SFWD	Monthly
Livestock Fecal	UCCE	2x / year
Wildlife Fecal	UCCE	6x / year
Grazing Management		
Livestock Health (Control Point 1)	Lessee	Annual & As needed
Fences (Control Point 2)	SFWD/ Lessee	Weekly & As needed
Grazing Utilization (Control Point 3 & 4)	SFWD/ Lessee	Monthly, Annual
Feral Pig Management	SFWD/ DF&G	Annual & As controlled
Recreation Management	SFWD/ EBRPD	Annual
Sunol FTP Management	SFWD	

Alameda Watershed
Physical Hazards Control Program

Plan Outline

The following is a *plan outline* which will be completed and included in the HACCP-based program for the Alameda Watershed.

<u>Hazard: Soil erosion and resulting sedimentation degrading water quality and filling reservoirs.</u>

Risk Assessment:

Sediment is a major carrier for pathogenic organisms, organic residues, nutrients, and pesticides. It can also clog stream channels and reduce the capacity of reservoirs. At the treatment plant, sediment causes additional problems. The increase in turbidity from the fine particles that do not settle to the bottom of waterways during the transport of sediment results in increased treatment operations (e.g. more backwashing of filters, higher disinfectant dosages). The risk of pathogens slipping through the treatment process is also increased.

Soil erosion and the resulting sediment can be from both natural and human induced sources. Natural soil erosion includes mass wasting (slumps, slides) natural streambank erosion, surface sheet and rill erosion and soil compaction. Human induced erosion includes mass wasting, gully and surface erosion from unsurfaced roadways, surface and gully erosion from improper road drains, excess sheet and rill erosion from overgrazed rangeland, soil compaction, grading activities (vegetation removal, pond repair, etc.) and feral pig rooting.

An accurate risk assessment of soil erosion and sedimentation and water quality requires a detailed inventory of problem sites, existing and potential mass movement sites, mileage, average width and condition of unsurfaced roadways, number, condition and location of roadway drains, rangeland utilization records, type and degree of grading activities and feral pig inventory and locations. Many of these factors can be evaluated in conjunction with the biological risk assessment portion in this report.

Critical Control Point 1: Minimize sheet, rill and gully erosion from unsurfaced roadways and stream culverts.

Best Management Practices:
Access Road with
- Proper road grading and design
- Proper road surfacing of critical areas

Road removal
Proper culvert design and placement
Proper trash rack design and placement
Proper road maintenance and stream crossing maintenance

Critical Control Point 2. Minimize sheet and rill erosion and stream sedimentation from grazing land.

Best Management Practices:
See "Livestock/Grazing Management" Section

Critical Control Point 3: Minimize soil erosion from graded areas

Best Management Practices:
Critical area planting
Buffer strips
Grade stabilization structures
Diversion

Critical Control Point 4: Minimize soil erosion from pig rooting

Best Management Practices:
See "Feral Pig Management" section

Monitoring, Critical Limits, Corrective Action, and Record Keeping will be completed according to implementation of work plan.

Alameda Watershed
Chemical Hazards Control Program

Plan Outline

The following is a *plan outline* which will be completed and included in the HACCP-based program for the Alameda Watershed.

Hazard: Contamination of source water from pesticides, herbicides, petroleum products or other chemicals.

Risk Assessment:

Alameda Watershed
HACCP-Based Water Quality Program

Work Plan

Date	Task
May -June 1997	Map grazing utilization. Measure residual dry matter (RDM). Include on utilization map locations of livestock water, supplemental feed, fences (including cross-fences) and other factors that may influence livestock distribution. Ground truth facilities data on GIS system. (See monitoring for Grazing/Livestock Management Critical Control Point 3 & 4).
May 1997	Collect elk and deer fecal samples. Include as many samples from elk calves and deer fawn as possible. SFWD can work with the University of California to establish protocol for collecting samples. The California Veterinary Diagnostic Laboratory Service can analyze samples. (See Watershed Monitoring Protocol)
May 1997	SFWD watershed managers meet with CA Dept of Fish and Game to plan and initiate an on-going, persistent plan for controlling feral pigs (See Feral Pig Management)
May-June 1997	SFWD watershed managers and lessees meet to review grazing utilization map and finalize grazing unit plan.
Summer 1997	Complete HACCP-based monitoring program to control physical and chemical hazards in the Alameda Watershed. Identify stock ponds that require maintenance, fencing or removal and alternative water developments. Identify roads that require maintenance, repair or removal.
Summer 1997	SFWD watershed managers meet with leasees, CA Dept of Fish and Game, CA Dept of Forestry and Fire Protection, East Bay Regional Parks District and other resource professionals to define resource objectives for each management (grazing) unit. Specific monitoring and management practices can be determined only after the resource objectives have been clearly defined and the HACCP-based water quality program is complete addressing biological, physical and chemical hazards.
Summer-Fall 1997	SFWD provides infrastructure i.e fences to implement grazing unit plan Riparian fences are constructed.
Fall 1997	Begin wildlife scat survey and wildlife fecal testing. (See Watershed Monitoring Protocol).

Fall 1997	Begin water quality sampling (See Watershed Monitoring Protocol).
Dec. 1997-Jan. 1998	Collect and analyze livestock fecal samples, include calves less than 4 months of age. (See Watershed Monitoring Protocol).
March-April 1998	Collect and analyze livestock fecal samples, include calves over 5 months of age. (See Watershed Monitoring Protocol).
May- June 1998	Update grazing utilization map. Measure residual dry matter (RDM). Include on utilization map locations of livestock water, supplemental feed, fences (including cross-fences) and other factors that may influence livestock distribution. (See monitoring for Grazing/Livestock Management Critical Control Point 3 & 4).
Summer 1998	SFWD watershed managers meet with lessees, CA Dept of Fish and Game, CA Dept of Forestry and Fire Protection, East Bay Regional Parks District and other resource professionals to review grazing utilization data and resource objectives for each management (grazing) unit. Recommend, if necessary, changes to watershed management practices.
Summer 1998	External HACCP-review team meets to review management and monitoring records.

Appendix I: Alameda Watershed
Grazing Unit Plan

History

Cattle have probably grazed the Alameda Watershed lands since the mission days in the late 1700's, and certainly since the Spanish/Mexican land grant era which ended around 1825 Most of the lands near the Bay were used primarily for livestock grazing until the 1860's, when fence laws were established to allow farming on the higher quality lands, and grazing moved into the rolling hill country. Grazing has been an ongoing use by both SFWD and predecessor, Spring Valley Water Company, since the mid-1890's. Today (1997) on the Alameda Watershed, there are 29 parcels leased for grazing domestic livestock (beef cattle and horses) involving 20 lessees and 30,890 acres. These 29 parcels are the current grazing management units within the watershed The parcels leased for grazing constitute the majority of the watershed not used for more intensive activities such as quarrying, nurseries, and golf courses A map of the lease parcels, including roads and boundary fences, is presented in Figure 6 (EDAW, 1995)

The watershed lands are typical of the Coast Range with wide variations in soils, slope, aspect, and vegetation. The landscape is dominated by annual naturalized grasses Since these annual plants germinate each year from seed, rainfall, temperature and residue (mulch) determine forage productivity and species composition from year to year. Residue (mulch) is the variable which can be controlled by management.

Since SFWD purchased and assumed management of the Alameda Watershed, the rangelands have undergone three periods of management (EDAW, 1995):

1930 to 1969. During this period, SFWD provided original fencing and water development. Leases were predominantly with neighboring ranch families and the cost of administering the leases was minimal. It is expected that the range resource was maintained in good condition because families managed their land solely to sustain their livelihood; for the same reason, lease terms were not particularly strict, practically open ended and easily amended.

1969 to late 1992. During this period, SFWD's primary objective was to maximize revenue from grazing leases. Bids for leases were forced to an open oral auction by threatened legal action, a process which drove lease fees higher and resulted in heavier grazing. Parcels were advertised for lease nationally, bringing lessees from a greater distance, usually transient livestock operators with unrealistic expectations about the carrying capacity of the range. There was a general degradation of facilities such as fences, water sources, and corrals. Drought periods in 1976-77 and 1987-91 resulted in heavy grazing of several parcels.

In 1986, when the watershed management program was initiated by SFWD, attention to watershed values increased, and the need for maintaining adequate vegetative residue (protection of ground cover) was recognized. Some monitoring practices were instituted.

1992 to present. During the past few years, grazing has been managed with an increased focus on watershed values and in anticipation of drought conditions. Leases are still acquired by bid, but screening of lessees was initiated in 1993. Screening measures include a review of a resume and history of operations, a financial statement, and letters of reference for all bidders. Improved maintenance of facilities by lessees, particularly water troughs and corrals, was evident by 1993-94. Stocking rates [expressed in terms of Animal Use Months (AUMs)] were reduced from the historical high levels of the previous period in two stages. Table 4 displays stocking levels and other lease parcel information, from historical high levels that prevailed from the mid-1970's and 1980's, through recent stocking rates (immediately prior to 1992) and finally the current stocking rates.

Overall Condition and Recent Improvements

The lack of vegetative residue (also referred to as Residual Dry Matter or RDM) during drought years--and even during favorable years in some locations within the watershed--has triggered concerns over livestock management, and its impact on watershed stability and water quality. Low residue situations have been documented by studies in 1990 and 1991, prior to the reductions in stocking rates. The philosophy of "highest bidder" created overuse of the land resources and generated conflict between SFWD staff and lessee. This in turn required greater staff time to address the problems which arose.

Since 1992, there has been a turnaround in range management on the watershed, as indicated in Table 4. The favorable climate in 1992-93 allowed the vegetation to recover from the drought. The lessees also became aware of new expectations of better management and facility improvement (Koopman, pers. comm.). During the winter of 1993-94, new water troughs and corrals were constructed. Today, communications between the lessees and SFWD staff has improved and there is a heightened awareness of what is required to manage a watershed for the primary purpose of providing high quality water. The willingness of the lessees to look critically at their parcels and identify areas that can be managed to protect water quality was evident as the Alameda County Resource Conservation District and the SFWD met with lessees to develop this Grazing Unit Plan.

Table 4. SFWD Alameda Watershed Grazing Parcel Lease Information

Parcel	Lessee/ Contact (Home)	Acres	Historical Stocking (AUM)	AUM/ Acre	Recent Stocking (AUM)	AUM/ Acre	Current Stocking (AUM)	AUM/ Acre
2	Erman Theodore (Pleasanton)	55	110	2.00	75	1.36	70	1.27
7	Alfred Medeiros (Fremont)	106	130	1.23	150	1.42	130	1.23
8	Robert Sanders (Escalon)	64	77	1.20	75	1.17	70	1.09
10	Jeff Cordtz (Sunol)	10	17	1.70	15	1.50	12	1.20
11	Pombo Farms (Tracy)	500	1200	2.40	550	1.10	450	0.90
12	Pombo Farms (Tracy)	385	650	1.69	460	1.19	360	0.94
13	Pombo Farms (Tracy)	160	320	2.00	225	1.41	145	0.91
20	Richard Mendoza (Oakdale)	290	480	1.66	420	1.45	270	0.93
21	Lawrence Williams (Sunol)	250	400	1 60	400	1.60	240	0.96
24	SV Golf Course Richard Mendoza-Sub (Oakdale)	333	500	1.50	500	1.50	415	1.25
32	Vassar Ranches (Dixon)	750	1200	1.60	1200	1.60	900	1.20
34	TN Cattle Company (Dublin)	1200	1800	1.50	1800	1.50	1200	1.00
35	TN Cattle Company (Dublin)	4405	4500	1.02	4000	0.91	3150	0.72
37	Pombo Farms (Tracy)	1601	2000	1.25	1500	0.94	1070	0 67

Parcel	Lessee/ Contact (Home)	Acres	Historical Stocking (AUM)	AUM/ Acre	Recent Stocking (AUM)	AUM/ Acre	Current Stocking (AUM)	AUM/ Acre
42	Stan Garcia (Pleasanton)	715	860	1.20	840	1.17	510	0.71
43	EBRPD Jim Coelho-Sub (Fremont)	1910	1670	0.87	1600	0.84	1060	0.56
44	EBRPD Fields Livestock-Sub (Castro Valley)	1000	1660	1.20	1200	0.87	840	0.61
45	EBRPD Fields Livestock-Sub (Castro Valley)	385	1660	1.20	1200	0.87	840	0.61
46	EBRPD Fields Livestock-Sub (Castro Valley)	1910	1910	1.00	1500	0.79	1080	0.57
47	Sparrowk Livestock (Clements)	9850	9000	0.91	7900	0.80	6150	0.62
50	John Covo (Milpitas)	37	50	1.35	45	1.22	35	0.95
51	Jack Bohan (Milpitas)	67	80	1.19	70	1.04	60	0.90
52	John Covo (Milpitas)	480	700	1.46	700	1.46	420	0.88
53	Fields Livestock (Castro Valley)	1961	1550	0.79	1500	0.76	1080	0.55
55	Fields Livestock (Castro Valley)	2100	2100	1.00	1600	0.76	1200	0.57
56	Ernest Wool (Milpitas)	160	160	1.00	150	0.94	120	0.75
60	William Airola (Farmington)	142	175	1.23	150	1.06	120	0.85
61	Lawrence Gronley (Sunol)	64	128	2.00	100	1.56	80	1.25
Totals	29 leases	30,890	33,427	1.08	28,725	0.93	21,237	0.69

Overview of Watershed Lands Not Owned By SFWD

SFWD owns only one third of the greater Alameda Creek watershed. However, activities on these upstream lands affect SFWD, as their watersheds drain into San Antonio and Calaveras Reservoir. These lands include inholdings which are surrounded by SFWD owned land, parcels adjacent to SFWD boundaries and parcels more remote.

Access to and development of lands within the watershed boundary are of concern from a water quality protection standpoint. Grazing which occurs on the lands owned by SFWD is conducted by SFWD lessees and is therefore under SFWD's control and management. Land parcels included or adjacent to SFWD influence the watershed both from development (houses and roads) and land use (grazing, hunting). Ranchers grazing outside the boundaries at the higher elevations are, for the most part, local and have an incentive for good management. Lands at the lower elevations are more subject to heavy use and may prove to be more of a problem when they become concentrated livestock areas (corrals rather than pastures) and horse arenas. Many of the ranchers leasing SFWD lands also run cattle on private lands or other public land in the Alameda Watershed. Sharing monitoring data and demonstrating science-based best management practices will likely influence how non-SFWD lands in the watershed are managed.

In addition, the Southern Alameda Creek Watershed Project directed by the Alameda County Resource Conservation District provides a good opportunity for involving the ranchers and landowners in watershed management, without the City being perceived as interfering with private property rights. This project would also provide an excellent forum to share monitoring data and encourage best management practices.

Lease Terms and Conditions

Previous lease terms and conditions were designed to protect SFWD and provide specific range management instructions to the lessee. They were based on the system of "high bidder" and assumed that the lessee would use the resources to the maximum extent possible. The recent shift to a bid/screening process is much more successful in terms of meeting watershed objectives. However, the parcel lease fee is currently based on a "per acre per year" basis, a historical method of cattle leasing in the area, which has a limited utility in apportioning the actual number and timing of cattle on the land. This makes it difficult to adjust stocking rates and season of use in accordance with forage availability and also encourages more intensive grazing. A change to the "animal unit month" (AUM) lease basis is recommended because it allows flexibility in the number and timing of cattle grazing; it is easier to make adjustments in lease fees; and it is consistent with the lease programs of adjacent agencies (i.e., the East Bay Regional Park District and East Bay Municipal Utilities District), as well as federal land management and other public land agencies

Normally, each lessee conducts their own weed control activities as a condition of the lease. However, during the last of the drought years, noxious weed control was conducted on SFWD lands through a contract with Alameda County. Ground squirrel control is also a lease condition, which requires the lessee to conduct annual poisoning. Lessees are also responsible for repair and maintenance of existing fences and gates and keeping stockwater ponds in a clean, well-maintained condition.

Grazing leases generated approximately $255,000 in revenue in the fiscal year 1992-93 (Koopman, pers. comm.). SFWD management costs have not been accurately tracked to determine if the revenues generated by grazing leases offset the costs of SFWD management, which include staff salaries, repairs and capital investment in range improvements.

Type and Class of Livestock

Grazing in the Alameda Watershed is most commonly associated with cattle grazing. Producers, market systems and, of course, consumers form the commercial basis of cattle, and provide a stable user group. However, sheep and goats, and even horses and llamas, are grazing animals with different combinations of program costs and benefits that can be considered. Sheep can be destructive grazers, but precisely because of this, sheep operations are frequently controlled by herders present on at least a daily basis. With properly trained dogs, sheep can be effective in highly area-specific pasture management. Goats, used for both meat and mohair, are "niche market" livestock for certain minority ethnic festival occasions and for mohair. This is a difficult market for a producer to successfully exploit, but goats have advantages for land managers. They readily browse on brush in dense stands, removing woody fuels, and have been used for many years for this purpose in Texas and more recently in several California counties. There are over 10,000 goats in California today. Since the vegetation in the Alameda Watershed is predominantly grass, cattle are the most suitable species for range management in most locations in the watershed; however, the SFWD may consider grazing other species to achieve specific resource objectives i.e. goats to control woody plants.

Class(age group) of cattle plays an important role in how cattle are distributed. Cows who are familiar with the range may help lead other cattle to specific locations distributing the cattle across the range. Using stockers requires introducing new cattle to the range each year. Cattle unfamiliar with the range may not distribute well on some range sites.

Proposed Actions To Implement BMPs for Livestock/Grazing Management Critical Control Points

Control Point 1. Request each lessee to submit a written plan of their herd health program.

Control Point 2. Fence riparian areas and reservoir pastures for each parcel as indicated under Special Management Considerations in Table 5. Define management for each area to achieve resource objectives.

In the Alameda watershed, reservoir pastures should be considered as an addition to an exclosure. Currently livestock access to the reservoirs is excluded, but the exclusion zone varies around each reservoir In areas where the current exclusion zone is narrow, riparian pastures (non-calf, non-corral pastures are designated. In areas where the current exclusion zone is wide, reservoir pastures within the exclusion are designated. These pastures may be grazed to control vegetation and temporary electric fence may be used to exclude livestock from the reservoir

In riparian areas, riparian pastures should be considered an alternative to exclosure area. They will not only provide a more substantial buffer to protect water quality than an exclosure area, but also be a manageable area. Riparian pastures should be managed based on defined resource objectives such as managing to improve riparian habitat and water quality. Management practices may include rest, controlled grazing, burning, pruning, and/or mowing.

Control Point 3. Measure residual dry matter (RDM) and map to verify and/or adjust current stocking rates for each parcel. Convert all current and future parcel leases to an animal unit month (AUM) basis to allow more flexible responses to yearly variations in forage availability. Management for each parcel should be based on achieving watershed/resource objectives.

Current stocking rate (AUM) should provide baseline AUM rates for each parcel (Table 4) Based on monitoring data as described for control point 3, stocking rate for grazing parcel on the Alameda Watershed should be evaluated to determine if resource objectives are being met Objectives such as fuel reduction goals (e.g., proximity to ignition sources)and ecological conservation (e.g., presence of riparian zones) should be considered in terms of water availability, fences or natural barriers and current use. Baseline AUM figures should be adjusted based on monitoring results.

Control Point 4: Review corrals and water developments in specific parcels as noted under Special Management Considerations in Table 5. Further assessment of areas of livestock concentration should be evaluated as monitoring is conducted.

Table 5. **SFWD Alameda Watershed - Physical Characteristics and Management Considerations**

Parcel No.	Acres	Drainage Unit[1]	Potential for Biological Hazards[2]	Current Livestock Type	Fire Risk[3]	Sensitive Wildlife Species	Ponds Springs Corrals	Sensitive Habitats	Special Management Consideration(s) for Controlling Biological Hazards
2	55	Outside S.F. Watershed Utilization Zone	None	Fall Cow/Calf	Low	None	P1	Kit Fox Habitat	None.
7	106	Outside S.F. Watershed Utilization Zone	None	Cow/Calf Yearling	Moderate	Western Pond Turtle	P2 S2 C1		None.
8	64	Outside S.F. Watershed Utilization Zone	None	Horses & Mules	Moderate	None			None.

[1] Due to limited time, those parcels outside S.F. Watershed utilization area will be addressed as plan is implemented.
[2] Potentials for biological hazards marked primary have drainage units surrounding and draining into reservoirs. Potentials for biological hazards marked secondary drainage units pass water through Sunol filter galleries.
[3] All areas at high to very high fire risk will be addressed by minimum AND maximum allowable residue levels.

Table 5. SFWD Alameda Watershed - Physical Characteristics and Management Considerations (Continued)

Parcel No.	Acres	Drainage Unit[1]	Potential for Biological Hazards[2]	Current Livestock Type	Fire Risk[3]	Sensitive Wildlife Species	Ponds Springs Corrals	Sensitive Habitats	Special Management Consideration(s) for Controlling Biological Hazards
10	10	Outside S.F. Watershed Utilization Zone	None	Horses	Moderate	None		Kit Fox Habitat	None.
11	500	Outside S.F. Watershed Utilization Zone	None	Dairy Replacement Heifers	Moderate	None	P4 S3 C1	Kit Fox Habitat	None.
12	385	Outside S.F. Watershed Utilization Zone	None	Dairy Replacement Heifers	Moderate	Western Pond Turtle, Burrowing Owl	P2 S2 C1	Kit Fox Habitat	None.

[1] Due to limited time, those parcels outside S.F. Watershed utilization area will be addressed as plan is implemented.

[2] Potentials for biological hazards marked primary have drainage units surrounding and draining into reservoirs. Potentials for biological hazards marked secondary drainage units pass water through Sunol filter galleries.

[3] All areas at high to very high fire risk will be addressed by minimum AND maximum allowable residue levels.

Table 5. SFWD Alameda Watershed - Physical Characteristics and Management Considerations (Continued)

Parcel No.	Acres	Drainage Unit[1]	Potential for Biological Hazards[2]	Current Livestock Type	Fire Risk[3]	Sensitive Wildlife Species	Ponds Springs Corrals	Sensitive Habitats	Special Management Consideration(s) for Controlling Biological Hazards
13	160	Lower Alameda Creek	Secondary	Dairy Replacement Heifers	Moderate	None	C1		Corral review and protection, if necessary. Minimum residue level for aesthetics.
20	290	Lower Alameda Creek	Secondary	Cow/Calf Yearling	High	None	P2 S2		Manage for fuel loading - Residue level not to exceed 1000 lbs./a and no less than 700 lbs./a.
21	250	Outside S.F. Watershed Utilization Zone	None	Fall Cow/Calf	Very High	None			Manage for fuel loading - Residue level not to exceed 1000 lbs./a and no less than 700 lbs./a.

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[1] Due to limited time, those parcels outside S.F. Watershed utilization area will be addressed as plan is implemented.

[2] Potentials for biological hazards marked primary have drainage units surrounding and draining into reservoirs. Potentials for biological hazards marked secondary drainage units pass water through Sunol filter galleries.

[3] All areas at high to very high fire risk will be addressed by minimum AND maximum allowable residue levels.

Table 5. SFWD Alameda Watershed - Physical Characteristics and Management Considerations (Continued)

Parcel No.	Acres	Drainage Unit[1]	Potential for Biological Hazards[2]	Current Livestock Type	Fire Risk[3]	Sensitive Wildlife Species	Ponds Springs Corrals	Sensitive Habitats	Special Management Consideration(s) for Controlling Biological Hazards
24	333	Lower Alameda Creek	Secondary	Cow/Calf Yearling	Moderate	None			None.
32	750	Lower Alameda Creek	Secondary	Fall Cow/Calf Yearling	Moderate	Tricolored Blackbird, Burrowing Owl, Badger	P1 S1 C1	Kit Fox Habitat	Riparian zone (fenced); Add new fence and develop water on upper side.

[1] Due to limited time, those parcels outside S.F. Watershed utilization area will be addressed as plan is implemented.
[2] Potentials for biological hazards marked primary have drainage units surrounding and draining into reservoirs. Potentials for biological hazards marked secondary drainage units pass water through Sunol filter galleries.
[3] All areas at high to very high fire risk will be addressed by minimum AND maximum allowable residue levels.

Table 5. SFWD Alameda Watershed - Physical Characteristics and Management Considerations (Continued)

Parcel No.	Acres	Drainage Unit[1]	Potential for Biological Hazards[2]	Current Livestock Type	Fire Risk[3]	Sensitive Wildlife Species	Ponds Springs Corrals	Sensitive Habitats	Special Management Consideration(s) for Controlling Biological Hazards
33		San Antonio Reservoir	Primary		Moderate	Golden Eagle 2-9-12, Western Grebe, Great Blue Heron, Horned Lark, Short-eared Owl, Osprey, Loggerhead Shrike 1-2, Burrowing Owl 4-5-6, White Pelican, Badger 2-3		Kit Fox Habitat	Add interior fence to define reservoir pastures, including electric fence to protect open water; Define management for riparian pasture to achieve resource objectives.
34	1200	San Antonio Reservoir	Primary	Yearling	Low	Golden Eagle 8-12, Loggerhead Shrike		Kit Fox Habitat	Fence riparian areas along Indian and San Antonio Creeks. Define management for these riparian areas to achieve resource objectives.

[1] Due to limited time, those parcels outside S.F. Watershed utilization area will be addressed as plan is implemented.
[2] Potentials for biological hazards marked primary have drainage units surrounding and draining into reservoirs. Potentials for biological hazards marked secondary drainage units pass water through Sunol filter galleries.
[3] All areas at high to very high fire risk will be addressed by minimum AND maximum allowable residue levels.

Table 5. SFWD Alameda Watershed - Physical Characteristics and Management Considerations (Continued)

Parcel No.	Acres	Drainage Unit[1]	Potential for Biological Hazards[2]	Current Livestock Type	Fire Risk[3]	Sensitive Wildlife Species	Ponds Springs Corrals	Sensitive Habitats	Special Management Consideration(s) for Controlling Biological Hazards
35	4405	San Antonio Reservoir	Primary	Cow/Calf	High	Western Pond Turtle, Golden Eagle 3-4-6, Prairie Falcon 1-2, Sharp-shinned Hawk 1-2	P8 S8 C1	Kit Fox Habitat	Fence riparian areas along Indian and San Antonio Creeks. Define management for these riparian areas to achieve resource objectives. Designate Williams gulch area as non-calf non-corral pasture. Review corral placement.

[1] Due to limited time, those parcels outside S.F. Watershed utilization area will be addressed as plan is implemented.
[2] Potentials for biological hazards marked primary have drainage units surrounding and draining into reservoirs. Potentials for biological hazards marked secondary drainage units pass water through Sunol filter galleries.
[3] All areas at high to very high fire risk will be addressed by minimum AND maximum allowable residue levels.

Table 5. SFWD Alameda Watershed - Physical Characteristics and Management Considerations (Continued)

Parcel No.	Acres	Drainage Unit[1]	Potential for Biological Hazards[2]	Current Livestock Type	Fire Risk[3]	Sensitive Wildlife Species	Ponds Springs Corrals	Sensitive Habitats	Special Management Consideration(s) for Controlling Biological Hazards
37	1601	Lower Alameda Creek, San Antonio Reservoir	Primary	Dairy Replacement Heifers	High	Great Blue Heron, Golden Eagle 1-2	P12 S1		Fence riparian areas along Indian and San Antonio Creeks. Define managment for these riparian pastures to achieve resource objectives. Need water development and repair of existing water facilities for east side with fencing around pond - small pond should be removed.

[1] Due to limited time, those parcels outside S.F. Watershed utilization area will be addressed as plan is implemented.
[2] Potentials for biological hazards marked primary have drainage units surrounding and draining into reservoirs. Potentials for biological hazards marked secondary drainage units pass water through Sunol filter galleries.
[3] All areas at high to very high fire risk will be addressed by minimum AND maximum allowable residue levels.

Table 5. SFWD Alameda Watershed - Physical Characteristics and Management Considerations (Continued)

Parcel No.	Acres	Drainage Unit[1]	Potential for Biological Hazards[2]	Current Livestock Type	Fire Risk[3]	Sensitive Wildlife Species	Ponds Springs Corrals	Sensitive Habitats	Special Management Consideration(s) for Controlling Biological Hazards
42	715	Lower Alameda Creek	Secondary	Fall Cow/Calf	Very High	None			Manage for fuel loading - Residue level not to exceed 1000 lbs./a and no less than 700 lbs./a.
43	1910	Lower Alameda Creek	Secondary	Fall Cow/Calf	Very High	Golden Eagle, Sharp-shinned Hawk	P6 S6 C1		Manage for fuel loading - Residue level not to exceed 1000 lbs./a and no less than 700 lbs./a.
44	1000	Lower Alameda Creek	Secondary	Fall Cow/Calf	Moderate	None			Fence riparian area along Alameda Creek - east of Calaveras Road. Define management for this riparian area to achieve resource objectives.

[1] Due to limited time, those parcels outside S.F. Watershed utilization area will be addressed as plan is implemented.
[2] Potentials for biological hazards marked primary have drainage units surrounding and draining into reservoirs. Potentials for biological hazards marked secondary drainage units pass water through Sunol filter galleries.
[3] All areas at high to very high fire risk will be addressed by minimum AND maximum allowable residue levels.

Table 5. SFWD Alameda Watershed - Physical Characteristics and Management Considerations (Continued)

Parcel No.	Acres	Drainage Unit[1]	Potential for Biological Hazards[2]	Current Livestock Type	Fire Risk[3]	Sensitive Wildlife Species	Ponds Springs Corrals	Sensitive Habitats	Special Management Consideration(s) for Controlling Biological Hazards
45	385	Lower Alameda Creek, Calaveras Reservoir	Primary	Fall Cow/Calf	Moderate	None	P3 S2 C1	Area of Potential Serpentine Associated Species	Designate parcel as reservoir pasture. Fence riparian area along Alameda Creek. Define management for this riparian area to achieve resource objectives.
46	1910	Lower Alameda Creek, Upper Alameda Creek	Primary	Fall Cow/Calf	Moderate	Pallid Bat, Western Pond Turtle, Foothill Yellow-legged Frog 1-2	P1 S1 C1	Area of Potential Serpentine Associated Species	Fence riparian area along Alameda Creek. Define management for this riparian area to achieve resource objectives.

[1] Due to limited time, those parcels outside S.F. Watershed utilization area will be addressed as plan is implemented.
[2] Potentials for biological hazards marked primary have drainage units surrounding and draining into reservoirs. Potentials for biological hazards marked secondary drainage units pass water through Sunol filter galleries.
[3] All areas at high to very high fire risk will be addressed by minimum AND maximum allowable residue levels.

Table 5. SFWD Alameda Watershed - Physical Characteristics and Management Considerations (Continued)

Parcel No.	Acres	Drainage Unit[1]	Potential for Biological Hazards[2]	Current Livestock Type	Fire Risk[3]	Sensitive Wildlife Species	Ponds Springs Corrals	Sensitive Habitats	Special Management Consideration(s) for Controlling Biological Hazards
47	9850	Lower Alameda Creek, Calaveras Reservoir, Upper Alameda Creek	Primary	Cow/Calf	High	Prairie Falcon 3-4, Golden Eagle, Cooper's Hawk, Black-shouldered Kite, Great Blue Heron, Horned Lark, Aleutian Canada Goose	P9 S4 C1		Fence riparian area along Calaveras Creek (where accessible). Define management for this riparian area to achieve resource objectives. Designate Long Field, Cherry Knoll and pastures on the southern end of the reservoir as reservoir pastures. Review corral facilities on the east side of the reservoir.

[1] Due to limited time, those parcels outside S.F. Watershed utilization area will be addressed as plan is implemented.
[2] Potentials for biological hazards marked primary have drainage units surrounding and draining into reservoirs. Potentials for biological hazards marked secondary drainage units pass water through Sunol filter galleries.
[3] All areas at high to very high fire risk will be addressed by minimum AND maximum allowable residue levels.

Table 5. SFWD Alameda Watershed - Physical Characteristics and Management Considerations (Continued)

Parcel No.	Acres	Drainage Unit[1]	Potential for Biological Hazards[2]	Current Livestock Type	Fire Risk[3]	Sensitive Wildlife Species	Ponds Springs Corrals	Sensitive Habitats	Special Management Consideration(s) for Controlling Biological Hazards
50	37	Calaveras Reservoir	Primary	Fall Cow/Calf	Low	None			None; Area is remote; No creek/stream access.
51	67	Calaveras Reservoir	Primary	Cow/Calf Yearlings	Low	None			None; Area is remote; No creek/stream access.
52	480	Calaveras Reservoir	Primary	Fall Cow/Calf	High	None	P2		None; Area is remote.

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[3] All areas at high to very high fire risk will be addressed by minimum AND maximum allowable residue levels.

Table 5. SFWD Alameda Watershed - Physical Characteristics and Management Considerations (Continued)

Parcel No.	Acres	Drainage Unit[1]	Potential for Biological Hazards[2]	Current Livestock Type	Fire Risk[3]	Sensitive Wildlife Species	Ponds Springs Corrals	Sensitive Habitats	Special Management Consideration(s) for Controlling Biological Hazards
53	1961	Calaveras Reservoir, Upper Alameda Creek	Primary	Fall Cow/Calf Yearlings	Very High	Golden Eagle	P1 S1		None; Area is inaccessible along Arroyo Hondo due to terrain; Otherwise parts of this parcel are remote with rugged terrain.
55	2100	Calaveras Reservoir	Primary	Fall Cow/Calf	Moderate	None	P4 S1 C1		Minor fencing along inaccessible area.
56	160	Calaveras Reservoir, Lower Alameda Creek	Primary		Low	None			None; Area is remote.

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[2] Potentials for biological hazards marked primary have drainage units surrounding and draining into reservoirs. Potentials for biological hazards marked secondary drainage units pass water through Sunol filter galleries.
[3] All areas at high to very high fire risk will be addressed by minimum AND maximum allowable residue levels.

Table 5. SFWD Alameda Watershed - Physical Characteristics and Management Considerations (Continued)

Parcel No.	Acres	Drainage Unit[1]	Potential for Biological Hazards[2]	Current Livestock Type	Fire Risk[3]	Sensitive Wildlife Species	Ponds Springs Corrals	Sensitive Habitats	Special Management Consideration(s) for Controlling Biological Hazards
60	142	Calaveras Reservoir	Primary	Cow/Calf Yearlings Horses	Moderate	None			None; Area is remote; No major drainageways.
61	64	Lower Alameda Creek	Secondary	Cow/Calf	Low	None	P1		None; Area is remote; No direct access to creeks/streams.

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[2] Potentials for biological hazards marked primary have drainage units surrounding and draining into reservoirs. Potentials for biological hazards marked secondary drainage units pass water through Sunol filter galleries.

[3] All areas at high to very high fire risk will be addressed by minimum AND maximum allowable residue levels.

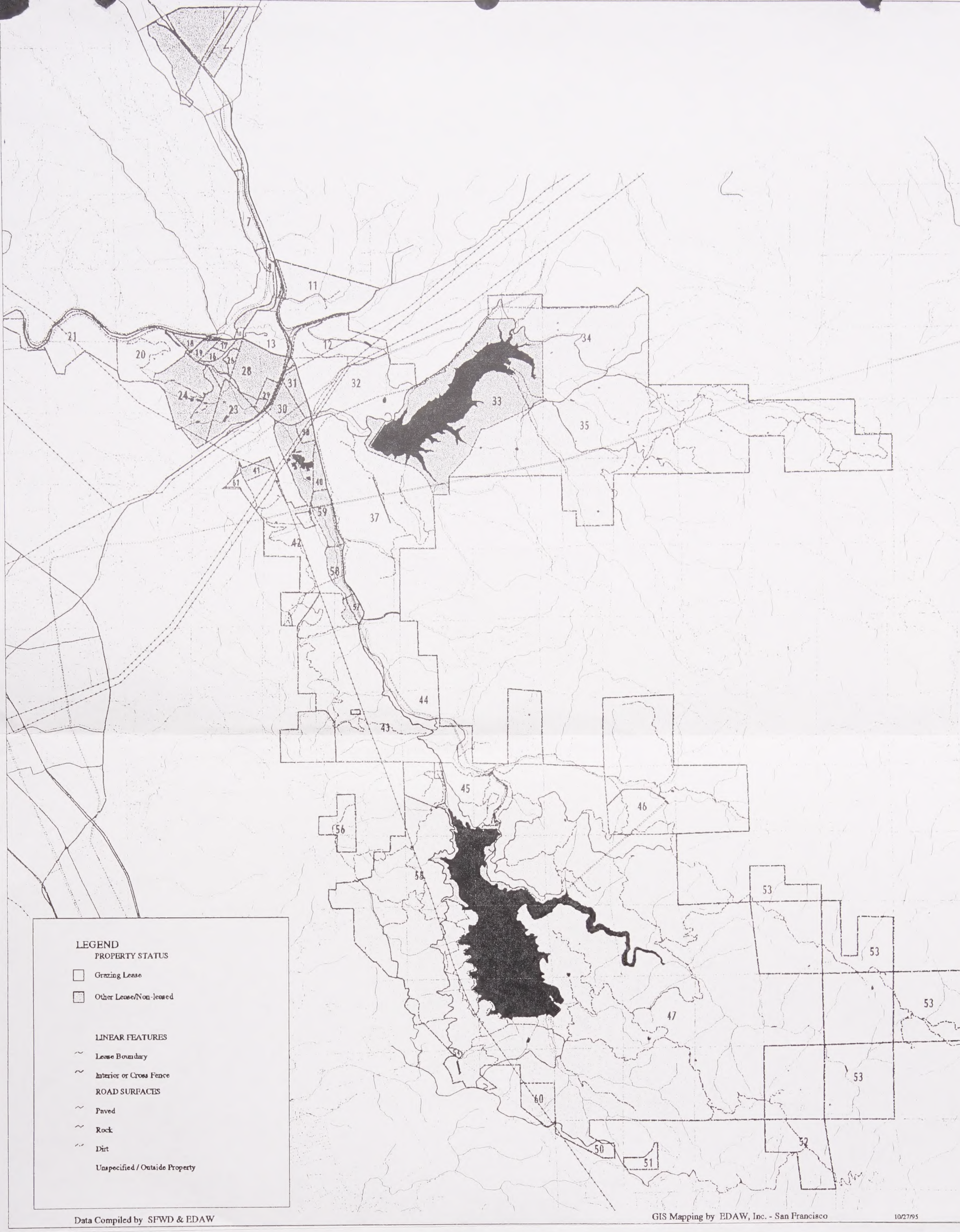

Figure 6

Leases and Grazing Status (draft)

Feet 1000 0 2000 4000 6000

Meters 500 0 1000 2000

Original Scale 1 : 24,000

N

ALAMEDA WATERSHED

SAN FRANCISCO WATERSHED MANAGEMENT PLANS